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# China Report

ECONOMIC AFFAIRS

ENERGY: STATUS AND DEVELOPMENT --XXX

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24 August 1984

## CHINA REPORT

### ECONOMIC AFFAIRS

#### ENERGY: STATUS AND DEVELOPMENT -- XXX

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## NATIONAL POLICY

### PROPOSAL WOULD MAKE NORTHERN ANHUI THE 'RUHR' OF CHINA

Beijing NENG YUAN /JOURNAL OF ENERGY/ in Chinese No 2, 25 Apr 84 pp 10-12

/Article by Qian Jinxi /6929 0093 2497/ and Chen Huizeng /7115 1979 1073/:  
"The Layout of the Northern Anhui Energy Base"/

/Text/ Many famous energy producing regions in the world started their industry with energy resources and energy plays a leading role in regional economic development. Energy resources are key indicators in the analysis and planning of regional economic development. In this paper we use the Ruhr industrial zone in the Federal Republic of Germany to discuss the economic development of the northern Anhui energy base in China.

The Ruhr is located in the west-central part of the Federal Republic of Germany. Based on its superior geographic location at the crossroads of central Europe, its convenient transportation, rich coal mines and natural environment for industrial and agricultural development, the Ruhr rapidly grew to become the largest heavy industry base in western Europe. The importance of the Ruhr in the Federal Republic is reflected in the following statistics: it has 33 percent of the total number of workers in the nation, its industrial value of production is 25 percent of the national total, it produces 83 percent of the coal, 60 percent of the copper, and has a high concentration of the machine building, electrical, petrochemical, automotive, and munitions industries.

The northern Anhui plains have the Liang Huai /Huainan and Huaibei/ coal fields, which have 99 percent of the coal reserve in Anhui and 52 percent of the coal reserve of eastern China, and rich iron ore and the transportation and agricultural conditions are also better than that of the Ruhr industrial zone. And yet northern Anhui is weak in all industries except coal production. As a result, the per capita value of production in resource-rich Anhui is very low, ranking next to last in eastern China, only slightly better than that of Jiangxi. Coal and iron from Anhui must be transported all the way to Shanghai and southern Jiangsu for processing and the industrial products are then shipped back to Anhui. Faced with such an irrational arrangement for production, we should combine the foreign experience with the Chinese reality and investigate the proper layout for the general development in Anhui.

The Ruhr coal field has an area of 6,200 square kms and a population of 5.68 million. The coal reserve is 65.2 billion tons within 1,200 meters and 92-104

billion tons within 1,500 meters. The Ruhr produces a good variety of coal including 59 percent fat coal suitable for coking, 22 percent flame coal and gas coal, and 15 percent calcinating coal containing 12-19 percent of volatiles, and 4 percent lean coal and anthracite.

The northern Anhui plains have an area of 54,606 square kms and a population of 23.18 million. The Liang Huai coal fields have an area of 10,000 square kms and a population of 17 million. Both are greater than the Ruhr. The Liang Huai coal field consists of the Huainan and the Huaibei coal fields. Up to the end of 1981, the confirmed coal reserve was 22.27 billion tons within 1,000 meters, 43.72 billion tons within 1,200 meters, and 70.23 billion tons within 1,500 meters. The variety of coal is good, including 74 percent gas coal suitable for coking, 6 percent fat coal and 3 percent coking coal. The sulphur content is less than 1 percent, the phosphorus content is less than 0.05 percent and the heat value per kg is 6,000-8,000 kcal. The coal of the Liang Huai fields has good quality, variety and reserve. The distribution of coal is good, the inclination of the coal seam is gradual and favors the construction of large-scale mechanized mine shafts.

On the other hand the Liang Huai coal fields also have a number of shortcomings. For example, the covering layer is thick (120-770 meters in Huainan and 70-450 meters in Huaibei for new mine shafts) and there is quicksand, the geological structure is complicated by faults and magma, the ash content of the coking coal is high (15-28 percent in the raw coal), part of the coal seam is located under densely populated cities, highways, and farms, and the mining of the coal is labor intensive.

In 1981 the Huainan-Huaibei coal fields produced 21.93 million tons of raw coal. This is 19.5 times the output before the Revolution and accounts for 90 percent of the output in Anhui. The coal production in Anhui ranked the sixth in the nation.

A reasonable layout of the production force is always based on the objective laws of economics and the needs of the society and makes use of the optimum arrangement to maximize the economic benefits. If the location of an enterprise is near the place of origin of raw material and energy and at the same time close to the place of consumption, that would naturally be ideal. But in most cases both advantages are not available simultaneously and one has to weigh the importance of energy, raw material, auxiliary material, and product on the basis of the technical and economic characteristics of the enterprise under consideration. Based on this principle, the Federal Republic of Germany developed its heavy industry base in the Ruhr.

The Huainan and Huaibei coal fields on the northern Anhui plains are located in the heartland of the Chang Jiang delta economic zone centered at Shanghai and serve as the energy and raw material bases for the Shanghai economic zone. Based on the objective principle of production force layout, it makes more sense to build the eastern China heavy industry base on the energy and iron-rich northern Anhui plains than to locate it on the coast where energy and raw material are in short supply. Therefore, we suggest that the northern Anhui plains be built into the "Ruhr" of eastern China, that is, into an industrial base for coal, steel, electric power, machine building, chemicals and building materials.

Although the coal mining industry in Liang Huai is making good progress, its coal dressing industry is not adequately developed. Today the coal washing plant in Huainan produces 3.5 million finished coal per year and the dressed coal is less than 30 percent of the total coal output. About 30 percent of the rest of the raw coal and washed coal is used for electric power production and 70 percent is used as noncoking coal. The economic efficiency is low and the situation is badly in need of improvement. We suggest that the percentage of dressed coal should be gradually increased to 40 percent of the raw coal output so that the finished coal may be used in the metallurgical and chemical industries in eastern China and in northern Anhui and the washed coal and peat may be used as noncoking coal and for power production in northern Anhui. This would increase the economic benefits and reduce the amount of coal transported by rail and by ship. In any case, for the purpose of an improved coal utilization rate techniques which would not only produce more finished coal but also more coke and coking byproducts such as coking gas, coal tar, crude benzene and ammonia. We may also produce coal gas and gradually move toward combined operation of coal-electricity, coal-chemical, coal-steel or coal-electricity-chemical-steel.

Coal is the basis for the economic modernization of the northern Anhui and even the eastern China. A sound layout of the entire coal industry on the northern Anhui plains is the foundation for further developments in the other departments of the economy.

The most desirable layout of the steel industry is the proximity to coal mines and iron ore, or at least one of the two. For example, the coal-rich Ruhr needs iron ore from Lorient, France; the iron-rich Great Lakes of the United States needs coal from the Appalachians; and the Soviet Union shuttles iron ore from Magnitogorsk and coal from Kuzbass and built steel mills in both places. In comparison, the northern Anhui plains have both coal and iron ore and have the most desirable and valuable conditions for the steel industry.

The total iron ore reserve in northern Anhui is 890 million tons; together with the Maanshan iron ore in southern Anhui, the total reserve in Anhui Province is as high as 2.5 billion tons and ranks fourth in the nation, next only to Liaoning, Sichuan, and Hebei. Anhui is the largest iron ore mining zone in southern China and is the only large iron ore base in eastern China.

In contrast, the Ruhr has no iron ore and relies on imported ore. Northern Anhui is in a better position than the Ruhr in this regard. However, due to the lack of attention in the past on the layout of the steel industry, today's steel industry in northern Anhui is very weak. There are only four small steel mills in Huainan, Bengbu, and Suxian, producing approximately 30,000 tons of steel and iron a year. Although southern Anhui has Magang, Hegang, and Wugang, the sizes of the steel mills are still way out of proportion to the large reserve.

The raw material, fuel and products of the steel industry are all heavy and bulky and are not suitable for long-distance hauling. In the spirit of a rational layout and an improved economic efficiency, we suggest that the steel mill site be selected from Huoqiu in northern Anhui, Huainan, or Suian. The

site should not be directly over a coal reserve and there should be an ample water supply. A steel mill of sufficient size is needed to play the role of the "Ruhr" of eastern China and to develop the local economy as well as that of eastern China.

When we draw on the Ruhr experience we should notice the importance of cross-departmental joint operations. The Ruhr has made considerable achievements in its coal and steel joint operation and its coal and electric power joint operation. The resource conditions of northern Anhui are better and there should be a coal-iron-steel joint venture.

There is a shortage of electric power in eastern China but the development of the heavy and chemical industries requires a prior, or at least simultaneous, development of electric power. Therefore, the coal-rich northern Anhui must step up the construction of the electric power industry. In 1981, northern Anhui only produced 950,000 kW of electricity or 9.5 percent of the eastern China power grid capacity. The annual consumption of coal, 3.2 million tons, is 15 percent of the coal output of Liang Huai. Anhui, in fact, is short of electric power by 20 percent, so we suggest that existing thermal power plants in Liang Huai should be expanded and new plants should be built. Power plants built at the coal mine sites in Huainan may deliver the power produced to Nanjing and Jiangyin via 500 kV transmission lines. The electric power output of Huainan could reach 1.16 million kW in 1985 and 3.5 million kW in 1990. The output of Huaibei could reach 1.65 million kW in 1985 and 1.95 million kW in 1990. Only then can northern Anhui provide enough electric power for eastern China.

Coal-rich northern Anhui is naturally ideal for the development of the chemical industry. Today, the value of production of the chemical industry in northern Anhui is 38 percent of that of Anhui and the products include ammonia, pure methyl alcohol, ammonium nitrate, concentrated nitric acid, benzene, and naphthalene. Many of the products still cannot satisfy local needs. For example, Huaibei produces 70,000 tons of chemical fertilizer per year, but the amount of chemical fertilizer used per mu is very small. If the application is doubled, then 200,000-300,000 tons will be required. The amount of caustic soda needed annually is 50,000-60,000 tons but only 6,000-7,000 tons are produced. We therefore recommend the construction of a large-scale synthetic ammonia plant in Huaibei to produce 300,000 tons per year. The investment will be 300-400 million yuan and, after production begins, 80-100 million yuan can be recovered annually and the Huaibei peasants will gain 300 million yuan per year from increased production. In Huainan, a complete coal chemical enterprise with coke as the main product may be built on the basis of the Huainan chemical fertilizer plant. In addition to coke, it can also produce 200,000 tons of synthetic ammonia and 10,000 tons of polyamine fiber. In the meantime, the machine coke produced by the plant can be used to replace the coke and 300,000 tons of coal can be saved annually. It may provide 360,000-400,000 cubic meters of coking gas and supply Huainan municipality and Hefei municipality with coal gas to conserve coal used in daily life and improve the people's life and the environment. In addition, the rock salt from Dingyuan may be used to produce pure alkali, methyl alcohol and ammonium chloride. Agricultural byproducts such as cotton seed shell may be used by furfural plants, yams may be used in the production of butanone and acetone and taro paste may be fermented to produce citric acid.

Liang Huai has accumulated 30 million tons of unprocessed coal rock and 4 million tons will be added every year. The power plant disposed 1 million ton of coal ash and the quantity will grow to 2.5 million tons by 1990. Both take up large area of land and seriously pollute the environment. If northern Anhui is to become the industrial base of eastern China, the large-scale development of the construction material industry is inevitable. We recommend the establishment of a coal rock-coal ash integrated utilization company to convert the wastes into useful construction material.

The machine building industry of the Ruhr was originally limited to coal mining equipment, boilers, and railroad equipment. Along with the mechanization of coal mines in the 1890's, the machine building industry of the Ruhr entered a new age. Today, it is capable of manufacturing complete metallurgical, coal mining, coking and chemical equipment and large cranes, locomotives, and vehicles. Based on a coal-steel-electricity joint venture and a well-developed transportation system, the scale of the Ruhr machine industry grew and diversified until finally a complete machine building industry was established. We should pay attention to this pattern of development.

The machine building industry in northern Anhui today is very weak, there is only a medium- to small-sized machine building business serving the coal mines and some machine repair shops. Major machines and equipment are brought in from outside the region. This is another flaw in the layout. In the future, based on a rational layout, the machine building industry can be gradually developed from the coal, steel, electric power and metallurgical industries.

In addition, transportation is also very important to an overall industrial base built on energy resources. The highly-developed river, railway, and highway transportation network has greatly helped the economic development of the Ruhr. Flat northern Anhui has been historically the hub of north-south traffic in China. Inside Anhui there are a number of railway and highway networks already built or under construction. The Chang Jiang and Huai He also provide some river transportation. If a canal can be built to link the two major river systems, then low-cost river transportation will play a greater role in transporting the coal, iron ore, and industrial products.

Furthermore, the installation of coal slurry pipelines in Huaibei, where the land is flat and the water is plentiful, is also much easier than in Shanxi and Nei Mongol. This should also be taken into account in planning a rational layout of the northern Anhui energy base.

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## POWER NETWORK

### GUIDELINES FOR ELECTRIC POWER DEVELOPMENT IN YUNNAN

Beijing NENG YUAN [JOURNAL OF ENERGY] in Chinese No 2, 25 Apr 84 pp 5-7

[Article by Lu Xiumin [7120 4423 2404] of the Kunming of Hydropower Survey and Design Institute, Ministry of Water Conservancy and Electric Power: "Guidelines for Yunnan's Electric Power Development"]

[Text] Today Yunnan has a severe shortage of energy. Since 1982 Yunnan has been buying electricity from power grids inside and outside the province. In the first 6 months of 1983 alone, 215 million kWh of electricity were bought at a cost of 10.2 million yuan and [the province] lost more than 60 million yuan in agricultural and industrial production. It seems that the shortage situation will not change any time soon. Why does a resource-rich province like Yunnan suffer from such a severe power shortage? In this paper we look back in history and analyze the cause for today's electric power shortage and explore the direction and guidelines of Yunnan's electric power development.

#### I. Historical Background

Due to a series of flip-flops and errors in Yunnan's energy policy in the past, the direction of energy development in the province has been unclear. Whether priority should be given to hydroelectric power or thermal power, large hydropower stations or small hydropower stations went undetermined. In terms of the selection of hydropower development, it was not clear whether we should go to the mainstream or stay on the small tributaries and whether we should work on high water heads or small flow rates. In terms of hydropower versus thermal power, people have always thought that the development of hydropower is slow and requires large investments and the supply of electric power is unstable. In Yunnan there has been a lot of talk about "work on both hydropower and thermal power, give hydropower the priority and use thermal power to meet short-term urgent needs" as the guideline for electric power development. On the surface, "work on both hydropower and thermal power" did not deviate from the national policy of electric power development and "give hydropower the priority" also pointed out the direction for the major effort. But how do we reconcile the guidelines of "working on both" and "giving hydropower the priority?" In allocating funds and arranging early phase work and construction projects, it was generally believed that long-term solutions do not help short-term problems and, once a shortage occurred, thermal power was looked to for "emergency measures." This has become a mode of operation in

Yunnan's electric power development. Before 1970, thermal power always dominated the scene. After 1970, hydropower stations on the Li He, Xi'er He, Lushui He, and Dazhai He subsequently came on line and the percentage of hydropower increased. However, a good portion of the hydropower stations are small county and prefecture level stations. As of the end of 1981, the generator capacity of all the small hydro stations in Yunnan was 504,400 kilowatts, which accounts for 45 percent of the total hydropower capacity 1,123 million kilowatts in Yunnan. These small hydro stations were mismanaged and trouble prone and the full benefits cannot be derived. By the year 2000, even if Lubuge and Manwan are completed, thermal power would still need another 2.058 million kW or 50.85 percent, higher than the 32 percent of 1981. Under these conditions, the advantages of hydroelectric power in Yunnan still cannot be developed.

## II. Yunnan Must Establish a Policy To Give Hydropower the Priority and Let Thermal Power Be the Auxiliary Source

Energy resources in Yunnan: Yunnan has abundant hydropower, coal, oil shale, geothermal, wind, solar, and uranium (235) resources. The most available, reliable and developed resources are coal and hydropower. In particular the development of water power resources has the advantages of integrated utilization, high efficiency, low cost, and broad benefits. The construction of a large hydropower station often brings with it the development of industry and agriculture, urban construction, tourism, transportation, ecological improvement, culture, and science and technology. Water is a renewable energy resource and, if not exploited, will be simply wasted. It is clean and pollution free, it is safe, reliable, versatile and serves to modulate the peak, frequency and phase of the system. It outperforms other electrical power sources in improving the operating conditions of the system. Once the problem of regulation of a large reservoir is solved, the problem of energy reserves is essentially solved. Other electric power sources cannot compete with this ability. Experience of the last 30 years shows that Yunnan must follow a direction of giving priority to hydropower development and using thermal electric power as an auxiliary source.

China has a hydropower reserve of 676 million kW out of which 379 million kW can be developed. Yunnan has 71 million kW of hydropower reserve, which is 20.5 percent of China's total reserve and is the second highest among the provinces. In terms of the land area and population, Yunnan has China's highest theoretical reserve and exploitable resources. But at the present time only 1.57 percent has been developed and the annual output of electric power is only 0.85 percent of the national total. Yunnan's hydropower resources have a bright future.

2. The superior development conditions of Yunnan's water resources favor the development of hydroelectric power.

Yunnan is located on the Yunnan-Guizhou plateau and the western part of the province is divided into high mountains and deep canyons by the crossing mountain ranges and rivers. Because of the large variation in altitudes, the rivers have large natural drops and the flow is rapid. The altitude is high in the north and low in the south, the southern part is close to the ocean and

has abundant rainfall. With the help of melting snow, the water volume of the rivers is large and stable. The main tributaries of the rivers not only favor large capacity hydropower generation, the guaranteed output is also high. With the help of cascade reservoirs, the guaranteed output is generally in the 40-50 percent range and the water resources are the best in the country.

According to the fifth water resources survey conducted in 1980, Yunnan has 600 rivers, 300 of them with a theoretical reserve of 10,000 kW or more. The theoretical reserve of hydropower in Yunnan is 104 million kW and the corresponding annual output is 907.89 billion kWh. Yunnan not only has a large amount of widely distributed hydropower resources, they are also suitable for the construction of all sizes of power stations, each with its own unique features. The largest hydropower stations will have a capacity of 10 million kW or so. Yunnan has six river systems but 82 percent of the water resources are concentrated on the Jinsha Jiang, Lancang Jiang and Nu Jiang. The hydropower stations that can be constructed not only have large capacities but also superior reservoirs and dam sites. The dam sites on the major rivers are mostly located in deep canyons with exposed rocks and superior geomorphic and geological conditions. The sedimentation layer of the river beds is thin and the development requirements are generally straightforward and uninvolved with other departments of the national economy. The construction tasks are relatively simple and require modest investment. The reservoir capacities are large, the flood losses are low and the relocation problems are easy to resolve. Each kilowatt of installed capacity is 1.5-2.5 m<sup>3</sup> /sic/ and the investment is generally 1,000 yuan or so, less than the national average.

In addition, the Yunnan plateau also has a large number of lakes. Yunnan province has more than 30 lakes with a total area of 1,000 square kms which hold 29 billion cubic meters of water. These lakes can be used for water storage, irrigation, and fish breeding and as regulatory reservoirs for hydropower stations, such as Dian Chi and Er Hai. Some lakes can also be used in pumped water storage power stations to modulate peaks and valleys and phase of the electric power system. The superior hydropower resources in Yunnan are ideal for the large-scale development of hydroelectric power production and the economic benefits will also be great.

3. The large amount of inexpensive electric power needed in the development of a variety of mineral resources dictates the development of hydroelectric power.

Yunnan is known as the kingdom of nonferrous metals. Yunnan has more than 100 of the 140 known useful minerals in the world. The province not only has rich reserves of a complete spectrum of minerals with a concentrated distribution favorable for mining, it also has a history of mining and has acquired mining and metallurgical processing abilities. Yunnan is also rich in phosphorus. The production of nonferrous metals and phosphorus requires large amounts of electric power and the electricity costs make up 20-40 percent or even 70 percent of the product cost. A 10,000-ton aluminum refinery requires 300,000-400,000 kW of electric power, a 10,000-ton zinc refinery requires 170,000-200,000 kW of electric power and a 300,000-ton electric furnace phosphorus refinery requires as much as 4.8 billion kWh of electricity per

year, equivalent to the total output of the Manwan power station. The electrolysis of 1 ton of yellow phosphorus takes 16,000 kWh of electricity which accounts for 50 percent of the production cost. If the price of electricity is reduced 0.01 yuan per kWh, the production cost of yellow phosphorus may be reduced by 160 yuan per ton. According to 1981 statistics, industrial use of electricity was 82.7 percent, out of which 50.9 percent can be attributed to the nonferrous metal and chemical industries. Electrical power is also essential to the textile, chemical, building material, and food industries and the people's daily needs. Due to the current shortage of electrical power, the development of these industries are hampered. If the price of electrical power is not reduced, the industries cannot afford the electricity even if it is made available. In 1980 the production cost of hydroelectric power in Yunnan was 1.06 fen per kWh and for thermal electric power it was 3.56 fen per kWh, or 3.4 times of that for hydroelectric power. Whether we use production value accumulation, profit or production cost profit as the criterion, hydroelectric power is higher than thermal electric power by a factor of 6 or 7. Therefore, Yunnan cannot afford not to develop hydroelectric power.

In addition, several of the world famous nonferrous metal mines have large or medium power stations nearby, such as the lead and zinc mine in Lanping, the tin mines in Maguan and Geyang, the iron mines and ferrous metal mines along the Lancang Jiang in southern Yunnan, and the phosphorus mines near Kunming. The combined development of power stations and mining not only provides an ample supply of inexpensive electric power but also avoids the long-distance transmission of electricity and reduces line loss and ore transportation. It lowers the investment in electric power and mining, reduces the refinery production cost and promotes the development of hydropower and the mining industry.

4. The structure of energy resources favors the preferential development of hydroelectric power.

The distribution of energy resources in Yunnan is characterized by the lack of coal in the west and shortage of water in the east. Coal is mostly concentrated in Zhaotong, Qujing, and Xiaolongtan in the east. The upper course of the Nanpan Jiang and Hongshui He in this area have a light flow and many dammed areas. The agriculture in this area is relatively developed and uses more irrigation water. In the low-water season, the rivers can only satisfy irrigation needs and little is left for hydroelectric power. The abundance of coal makes up for the shortage of hydroelectric power and the construction of power stations near mine shafts will develop the advantages of thermal power. Moreover, the pumped water energy storage power station at Fuxian Lake is located near a load center and is good for the regulation of the power grid. Although coal is in short supply in the western part of Yunnan, the area is rich in hydropower resources and has many large mineral reserves. This distribution of resources is unique to Yunnan.

Yunnan is also rich in coal. The confirmed coal reserve is 16.5 billion tons and the prospective coal reserve is more than 60 billion tons, ranked 12th in the country. However, 75 percent of the coal in Yunnan is low heat content brown coal and the per capita amount is only 63 percent of the national level. In contrast, the per capita hydropower resource is 6.88 times the national

level. It is therefore completely rational to give hydropower the priority and use thermal power as an auxiliary source. If hydropower does not receive priority in Yunnan, Guizhou and provinces in northwest China, it would be impossible to stress hydropower on a national level because other provinces do not have the advantage of a rich hydropower resource.

5. Promote the integrated use of energy and develop more hydropower stations.

The thermal energy of the Tertiary brown coal found is generally less than 400 kcal/kg and it is not very useful for cooking or as a fuel for boilers. However, the brown coal has a high chemical activity and transformation rate and can be made into crude coal gas under pressure and dozens of organic products can be extracted from it. It can also be purified to make synthetic methyl alcohol and coal gas or made into petroleum by the "constant pressure coal liquefaction method" to supplement the production of oil and gas, both of which are in short supply in Yunnan. Today, Yunnan has a thermal power generation capacity of 565,000 kW and burns one-third of the coal produced. Since the price of coal is unrealistically low--less than the production cost--each ton of coal supplied to the thermal power plant costs the state 10-17 yuan and the state subsidizes 46.85 million yuan every year. By the year 2000 Yunnan would need 2,058 million kW of thermal power and the state subsidy would be 170 million yuan even based on the present rate. A 1 million kW thermal power plant needs approximately 4.50 million tons of raw coal per year and in the year 2000 the thermal power plants alone would need 10 million tons of coal. This would put a great pressure on the coal industry. The development of hydropower would therefore serve the dual purpose of saving coal and developing the coal chemical industry and improving the integrated utilization of coal to reduce state subsidizing of coal prices.

6. To accumulate wealth for the state, we must develop more hydroelectric power.

Since the Revolution, Yunnan has built medium and small hydropower stations at Liulangdong, Yili He, Xi'er He, Lushui He, Dazhai, and Sanjiugushui. The total generation capacity is 657,000 kW and the money invested was 920 million yuan. Up to 1980 the accumulated electrical power output was 20.712 billion kWh and 983 million yuan were accumulated for the state. The Liulangdong station has the best economic efficiency and has been operated as much as 7,000 hours per year. Since 1960, when the Liulangdong station began production, the profits generated in the 23 years have been enough to build six more power stations of the same size. The Dazhai station began its production of electricity in 1977; it has been in operation for the last 6 years with 3-4 months of interrupted production per year. It has produced 720 million kWh of electricity and the value has long exceeded the state's investment in this station. If the Agang reservoir on the upstream is built, the output of the six generators in just 2 years will be equivalent to the investment in a Dazhai size power station. The Yili He power station, even though it took a longer construction time and require more money for construction, can bring in as much as 60 million yuan of income per year and took only 8 years to recover the investment. Hydropower stations usually take 3-5 years and at most 7-8 years to recover the investment but thermal power stations usually take 15-18 years. For the Xuanwei power

plant, the investment recovery time is estimated to be 28 years. The output and economic benefit data of the Yunnan electric power system for the last few years (see table below) also show that the higher the hydroelectric power output, the higher the profit. In contrast, the higher the thermal electric power output, the lower the profit. Therefore, if we are to accumulate profits for the state, we must develop more hydroelectric power stations.

Electric power output and profit in Yunnan for the last 3 years

Year	Thermal power (100 million kWh)	Hydropower (100 million kWh)	Annual profit (100 million yuan)
1981	18.85	28.91	1.16
1982	25.88	23.21	1.01
First half of 1983	13.65	8.13	0.6-0.7

Based on the discussion above, the policy of electric power construction in Yunnan should be "develop hydropower first and use thermal power as an auxiliary energy source." By implementing this policy, Yunnan will be able to build a power grid based on hydropower and supplemented by thermal power in which the cascade power stations complement each other. Such a power grid would have the advantages of both hydropower and thermal power and would be convenient to operate and the coal saved could be used to support the chemical industry.

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## POWER NETWORK

### BRIEFS

SHANXI TRANSMISSION LINE--On completion of the first Beijing-Datong 500,000-volt power transmission line project, the Shanxi Provincial power transmission and transformer construction company started the construction of the Shanxi section of the second Beijing-Datong 500,000-volt power transmission line project. This state key project is 289-kilometers long and runs parallel with the first power transmission line. The company will undertake the construction of the project only within the boundary of Shanxi Province. The transmission line in our province, 102.7 kilometers long, extends from the No 2 Datong power plant to the east through Datong City, Datong County, Yanggao County, and Guangling County, and joins with Hebei Province. [Summary] [Taiyuan SHANXI RIBAO in Chinese 7 Jun 84 SK p 1]

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## HYDROPOWER

### NEW APPROACH TO SHORTER CONSTRUCTION TIME, LOWER COSTS

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 11, 12 Nov 83 pp 3-5

[Article by the Editorial Department of SHUILI FADIAN]

[Excerpts] In the spirit of the Party Central Committee directive to speed up construction of hydropower stations and to shorten construction time, the Water Conservancy and Hydropower Construction Company studied the actual situation of the hydropower system and decided in July 1982 to develop potential, organize specialists, and fully develop the construction of the Hongshi hydropower station by adopting a specialized contract system. After more than a year of practice, results show that this management method has greatly shortened the construction time of the Hongshi project and it has turned into a major test in organization methods and shortening construction time for future hydropower construction.

The Hongshi hydropower station is one of the stations being built on the Di'er Songhua Jiang. It is located 35 kilometers from the Baishan hydropower station upstream and has a total capacity of 200,000 kilowatts. This pivotal project consists of a concrete gravity dam and riverbed type plant buildings. The maximum height of the dam is 46 meters and the dam uses comb tooth type diversion. The construction volume of the project consists of 750,000 cubic meters of earthwork, 520,000 cubic meters of poured concrete, 250,000 linear meters of curtain and adhesive grouting, and 2,500 tons of metal structures. The total engineering investment is 267 million yuan, the first generator is scheduled to produce electricity in 1986, and the project is expected to be completed in 1987. Moreover, since Engineering Bureau No 1, the unit responsible for the construction project already did some preparatory work in 1981, they are now working under an accelerated schedule. Also, by coordinating the construction of the Hongshi and Baishan stations, the construction time can be shortened without exceeding the budget. For example, according to the schedule the Baishan station will fill its lower reservoir after the flood season of 1982, if the Hongshi station construction crew can seize this opportunity of interrupted flow and make an all-out effort, the flow diversion of the Hongshi station will be greatly simplified. However, since the Baishan hydropower construction project is at the height of its activity, Engineering Bureau No 1 cannot divide its attention to work on the Hongshi project. Therefore, some decisive measures must be taken in a

timely manner to quickly resolve the lack of construction manpower; otherwise, once the opportunity is missed, the construction speed of the Hongshi station will be adversely affected.

In view of this situation, the Water Conservancy and Hydropower Construction Company held a site conference participated by the associated units and decided to make an all out effort in building the Hongshi hydropower station. After studying the problems, the conference decided to take the following measures: "(1) The Hongshi branch of Engineering Bureau No 1 will be the overall responsible unit and the other bureaus will contract the various construction tasks. Among those are the Gezhouba Engineering Bureau responsible for the left bank base excavation and the phase I earth and rock cofferdam construction; Engineering Bureau No 3 will be responsible for the installation of the concrete mixing system and the production of concrete; Engineering Bureau No 5 will be responsible for the installation of the sand and rock aggregate system and its production and operation; the Engineering Bureau No 6 will be in charge of the pouring of the concrete longitudinal coffer dam; concrete pouring of the dam body will be done by the Engineering Bureau No 7; the transportation of earth and rock work, concrete and sand and rock aggregate is the responsibility of Engineering Bureau No 13 and adhesive grouting will be handled by Engineering Bureau No 9. Tasks concerning the overall scheduling, the supply of air, water, electricity and material will be the responsibility of the Hongshi branch of Bureau No 1. (2) The contracting units will be responsible not only for the engineering task but also for the financial responsibilities. The various units will enter contracts with the Hongshi branch bureau based on the uniform budget quota for water conservancy and hydropower engineering. The economic responsibilities will be clearly defined and the following six items will be guaranteed: budget, work load, construction time, quality, cooperation, and work schedule. (3) All contracting units will organize well-equipped and competent teams without including dependents. They will bring along their own auxiliary equipment and for those not already available, the teams will fabricate them on their own. In short, the contracting units will solve their own problems in order to reduce the burden of the Hongshi branch. (4) Within each contracting unit, the division of work is also done on an economic contracting and responsibility system at the various levels. Economic management and accounting will be followed in order to improve productivity.

The Hongshi hydropower station construction project began in September 1982 and has been in progress for 1 year. In this period the organization methods described above have resulted in faster progress and considerable savings in investments.

First, the specialized contracting method has mobilized initiative in production and greatly improved production efficiency. Because the duties, assignments, and responsibilities were clearly spelled out, the contracting

units were able to send their best men with their good equipment and worked on the jobs right there and then according to the overall progress plan. Since it was a big operation, the contracting units and the teams and groups within the units competed with each other and the production efficiency was greatly improved. For example, in the past it took the Gezhouba Engineering Bureau 7 days to install a  $4\text{m}^3$  excavator, but at the Hongshi construction site they installed two units in 4 days. It used to take 15 days to install a  $40\text{m}^3$  compressor, but now it takes only 5 days. In addition, in the bitter cold of 30 degrees below zero, the submerged hole-drilling teams made 96 meters of footage advance and the manual pneumatic drill individual teams made 116 meters of advance, overfulfilling the quota by several folds. To install eight  $0.8\text{m}^3$  mixers and auxiliary temporary mixing systems, Engineering Bureau No 3 organized 120 men and completed the task in only 5 months. A 20-meter-tall hexagonal mixing tower was erected and the main machinery installed in 15 days. More than 500 workdays were saved in assembling the storage bin, the vacuum system, and the pipe system. The 170 workers of Engineering Bureau No 6 took over site clearance, form fabrication, tying reinforcement, and pouring concrete. Within 3 and one-half months, they built  $10,000\text{m}^2$  of thermal canopies, did  $5000\text{m}^2$  of foundation clearance, tied 87 tons of reinforcement, poured  $13,000\text{m}^3$  of concrete, and finished 1.2 million yuan of work at a record average of 7000 yuan per worker. The production rate of the entire Hongshi project in 1982 was 4,200 yuan per worker. In the first 8 months of 1983 the output has been improved to 5700 yuan per worker and set a record for hydropower systems in recent years.

Second, the prominent achievement of the Hongshi project is the shorter construction time and the completion of task ahead of schedule. According to the original construction organization design, the phase I earth and rock cofferdam should have achieved the spring runoff endurance standard by April 1983, and the concrete longitudinal cofferdam should have reached flood endurance standards in July 1982. After repeated studies by the design and construction units, a bold proposal was put forward to simplify the earth and rock cofferdam and to use the concrete longitudinal cofferdam to handle the 1983 spring runoff, a difficult and risky proposal. Under this circumstance, the various units all worked hard together, conquered the difficulties brought about by the bitter cold and, after 5 months, built the longitudinal cofferdam to the designed height on 10 April 1983, meeting standards for flood prevention. The original schedule called for the pouring of the comb tooth dam section after the 1983 runoff and the blocking of the river flow in 1984. Due to the hard work and collaboration of the contracting unit, the flow blocking was accomplished in September 1983, 1 year ahead of schedule.

Third, economic accounting has saved engineering investments. Cost overruns have been the concern of many comrades working on the Hongshi project. This worry was heightened because the work forces were called in from various places which increased the cost and some of the temporary facilities were expected to exceed the budget. However, after 1 year's practice, the situation has become quite clear: more money was indeed spent on some of the small items but on the whole there was actually a saving. This came about because (1)

The various units offered the "six-guarantees" and assumed the economic responsibility. Strengthened economic management and fiscal accounting prevented cost overruns. (2) Because the contracting unit sent a lean crew of workers to the construction site without dependents, the number of people (3,500 or so) at the construction site was reduced to half the designed number of 7000. This has greatly reduced the living facilities and the associated costs. Most strikingly, the building area was reduced from the originally planned 180,000 m<sup>2</sup> to 140,000 m<sup>2</sup>. (3) Most of the construction equipment was brought in by the contracting units, saving almost 10 million yuan. (4) The completion dates were moved up and the corresponding expenses were saved. Most importantly, since the whole construction time is shortened, power production may begin a year earlier if generator production can also be moved up correspondingly. The complete power station will provide inexpensive power for the northeastern area and alleviate the energy shortage to some degree. This would be the biggest saving.

Based on the discussion above, we believe that the specialized contracting and the large-scale dynamic operation of the Hongshi hydropower project are effective and proved that: (1) China's hydropower system has internal manpower and material potential that can be tapped and the heavy burden associated with the old practice of bringing families along and taking care of the children can be avoided. (2) It broke the old established system of "large and complete" and "small but complete" and opened up a new way of clearly defined assignments and responsibilities, competition among units and mutual collaboration and stimulation. (3) It helped to shorten the construction time, save the state's investments and improve the economic efficiency. Naturally this change is only a preliminary exploration and has not been practiced for very long. It still has some flaws such as the matching of investment and material supply to the construction progress. As a complete engineering project, the specific formulation of the contract method and the coordination at various level still need further study and improvement. But we do believe that, as long as we can consolidate experience and adhere to the right direction, we can definitely work out a new approach to speed up the construction of hydropower stations, shorten the construction time, and lower the engineering costs.

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## HYDROPOWER

### CONSTRUCTION OF BAISHAN AND ITS FUNCTION IN THE NORTHEASTERN GRID

Beijing SHULI FADIAN [WATER POWER] in Chinese No 11, 12 Nov 83 pp 5-7

[Article by Wang Yongrong [3769 3057 2837] of the Northeastern Survey and Design Institute of the Ministry of Water Resources and Electric Power"]

[Text] The Baishan Hydroelectric Power Station is one of 70 priority construction projects now underway in China, and it is the largest hydropower station in northeast China. The main body of the construction work began in May 1975, the reservoir was filled in November 1982, and the first 300,000 kilowatt generator is about to generate electricity. Effort is being made to put a second generator of equal capacity into operation by the end of the year. Once completed, the Baishan hydropower station will play an important role in the four modernizations of the northeastern region.

The Baishan power station is located on the upper course of the Di'er Songhua Jiang and is linked to the Hongshi station being built downstream and the Fengman station already in operation. The Baishan hydropower station is a large-scale power station whose principal function is power production and it also provides side benefits such as flood prevention. At a normal water level of 413 meters, the reservoir capacity is 5.13 billion cubic meters. The total generation capacity is 1.5 million kilowatts, the capacity per generator is 300,000 kW and the construction is divided into two phases. In the phase I construction, 900,000 kW in generator capacity will be installed in the underground power plant on the right bank, with a guaranteed output of 2.003 billion kilowatt-hours. The principal function of this station in the northeastern grid is peak regulation, frequency modulation, and incidence backup. Together with the Fengman station, the construction of the Baishan station will increase the guaranteed output of the Fengman station by 19,000 kW and the annual power production by 46 million kWh. With the stations put together, the Fengman reservoir output flow rate may be reduced by 500-1000 m<sup>3</sup>/sec for floods smaller than those that occur once every hundred years.

The Baishan hydropower station was designed by the Northeast Survey and Design Institute and Engineering Bureau No 1 is responsible for the construction. Over the years, all the survey, design, research, and construction personnel worked together diligently and obtained considerable results: (1) The geological survey was performed in great detail and the design was conducted

thoroughly. After the design was approved and the construction began, there were three design changes to enlarge the power station based on the needs of the power system development and the new situation of the August big 1975 flood in Henan Province. Even so, the layout of the main building structures remained the same and the main body construction did not increase. There were no repetitions in construction and the supply of technical service and blueprints satisfied the requirements of the construction and the equipment orders.

(2) The project followed rational, reliable principles and conducted great amount of computational analysis and experimental tests. The design adopted such new techniques as the three-centered [arch] concrete gravity dam, erosion reduction of the spillway surface, three-dimensional sluice energy dissipation, radial overlapping inlet layout, shortened steel lining of the high-pressure water guide, high-pressure grouting and prestressed concrete lining of the tunnel, and shotcrete and rockbolting. In the construction, new techniques such as unibody sliding forms, precracked blasting, fan hole blasting, underwater deep hole blasting, prestressed anchor cables and modular thermal canopies were used. All these new techniques have played an active role in insuring construction quality, shortening the construction time and improving the economic efficiency. (3) Since the scale of the power station was enlarged and the number of construction tasks was increased, together with wage and price adjustments and increase in management costs, the phase I construction budget of 638 million yuan approved in 1974 was increased by about 30 percent to 900 million yuan, but the investment per kilowatt was only 1000 yuan. After the phase II work (estimated cost: 230 million yuan) is completed, the per kilowatt investment will be reduced to 750 yuan, the lowest in today's hydroelectric power construction. Economically it is very competitive as compared to the costs of peak regulation with thermal power and the construction of power stations that pump water to store energy. (4) Although the construction of the Baishan hydropower station suffered from the disruption of "leftist" thought and wasted some time, after the Third Plenum of the 11th Party Central Committee, construction accelerated as the result of improvements and readjustments with the help of the leadership. The project eventually achieved the completion of the reservoir dam in 7 years and produced electricity in 8 years. Had it not been for the wasted time in the beginning, the schedule would have been moved up considerably.

The construction of the Baishan power station shows that under the guidance of the correct party line, the construction time of future hydropower projects can be made even shorter and the cost-efficiency can be made even better as long as improvements are made thoroughly, early phase survey, design and research are done well and the construction schedule is strictly adhered to.

In order to explain the status and function of the Baishan hydroelectric power station in the northeastern grid, we shall first describe the development and the present status of the power construction in the northeastern region.

The northeastern region is one of the important industrial bases in China. As the economic construction develops, the demand on electric power increases rapidly. Even though the power grid capacity has increased 15-fold during

the 30 years from 1951 to 1981 and doubled almost 4 times, it still cannot keep up with the economic growth in the region. Statistics show that the ratio of the power production capacity and the power consumption capacity in the entire region was 1:1.5 in 1956, basically satisfied the needs in industrial and agricultural production, and increased to 1:2.2 in 1978 and 1:2.5 in 1980. The widening gap has forced a number of enterprises to conduct their production constantly under limited supply of electric power, a large number of the electric power consuming facilities were idle or semi-idle, the electric power for light industry, agriculture, and for daily use by the population could not be guaranteed and the shortage was extremely acute.

In the last few years, along with the adjustment and development of the national economy, the electric power consumption of the northeastern region has undergone pronounced changes. The overall trend is a rise in power consumption in agriculture, transportation, and urban living and a drop in power consumption by industry. According to statistical data, industry used, on average, 90.6 percent of the electric power in the 1950's, 80.3 percent in the late 1970's, and 78.7 percent in the early 1980's. The agricultural use of electricity was 0.53 percent in the 1950's, 11.6 percent in the late 1970's, and 13.5 percent in the early 1980's. After the Third Plenum of the 11th Party Central Committee, electric power consumption within the grids shifted even faster. For example, agriculture accounted for 12.3 percent of the electric power used in 1979 and by 1981 this had increased to 13.68 percent, and the amount of electric power used rose by 19.3 percent. The percentage of industrial power usage has dropped from 80.92 percent in 1979 to 78.63 percent in 1981 and the amount of power used only increased by 4.1 percent. Transportation's use of electric power rose from 0.38 percent in 1979 to 0.48 percent in 1981 and the amount of power consumed increased by 32 percent in that period. The power consumed by urban living was 6.4 percent in 1979 and 7.21 percent in 1981 and the consumption increased by 20.7 percent.

Due to the situation described above, the load of the system has also undergone noticeable changes, the most striking being that the peak load has increased year after year and the peak-to-valley difference is getting greater and greater. Statistical data showed that the percentage of the peak load relative to the maximum load was 12-13 percent in the 1950's, 25-27 percent in the 1970's, and 33 percent in 1982. As can be expected, the peak-to-valley difference of the system will continue to increase as the material life of the society improves. At the present time the system only has 0.8-1.0 million kilowatts of peak regulation hydropower stations, about one-third to one-half of the peak load, and the remaining one-half to two-thirds must be taken up by thermal power. Using thermal power plants in peak regulation will invariably increase the consumption of coal and oil and the electrical power used by the plants and decrease the amount of power production. Nor can it satisfy the rapidly changing load demand. In addition, the frequent start-ups and shut-downs of the generators affect the safe production of electricity and is detrimental to the safe and economical operation of the system. The attempts to speed up the construction of the Baishan power station and other hydroelectric power stations is precisely aimed at solving

the urgent needs in the development of the northeastern power grid.

Based on the development situation of the northeastern power grid, one may predict the load level in the sixth and seventh five-year plans. Assuming an annual increase of 6.5 percent in the power production for the past 10 years, the maximum load in the winter of 1985 will be 11.2 million kilowatts. The phase I construction of the Baishan station involves the installation of three generators for a total of 900,000 kilowatts in 1983-1984. Together with other newly built and existing hydropower stations, the total capacity will be 17.1 percent of the maximum load of the system and the hydropower peak regulation capacity will be 44.5 percent of the peak load of the system. Out of the 900,000 kilowatts of the Baishan station, 220,000 kilowatts will be system reserve and the remaining 680,000 kilowatts will be used for peak regulation. This amounts to 42.8 percent of the hydropower peak regulation capacity in the latter phase of the Sixth Five-Year Plan and will supply 1-4 hours of the high peak load of 480,000 kilowatts and pick up the 200,000 kilowatts of mid-load in the winter of 1985. They represent respectively 18 percent of the peak mid-load and 25 percent of the peak load in the winter electric power balance diagram. The maximum load in the winter of 1990 may reach 16.11 million kilowatts and, according to the plan, the 600,000 kilowatt generation capacity of the phase II Baishan project is scheduled to come on line by 1990. At that time, together with other new construction and existing stations, the total capacity of the hydroelectric power will only be 17.7 percent of the maximum load of the system and the hydropower peak regulation capacity will only be 47 percent of the peak load of the system. The 1.5 million kilowatts of the Baishan station will be 46 percent of the hydropower peak regulation capacity at the end of the Seventh Five-Year Plan and will supply 0.995 million kilowatts for 1-5 hours at the peak load in the winter of 1990 and 150,000 kilowatts of the mid-load. These will be respectively 23.4 percent of the peak mid-load and 25 percent of the peak load in the electric power balance diagram for the winter of 1990. It is therefore clear that the 0.9-1.5 million kilowatts from the Baishan station in the sixth and seventh five-year plans will account for 25 percent of the peak regulation capacity of the system. Such a large percentage is very important for the safe and economical operation of the northeastern grid.

In order to use hydroelectric power as much as possible for peak regulation and insure the economical operation of thermal power production, it is stipulated in the forecasts that the maximum reserve capacity of hydropower will be 5 percent of the maximum load of the system, out of which 3 percent will be load reserve and 2 percent will be accident reserve. After the 900,000 kilowatts from the phase I Baishan project come on line, the reserve capacity of 220,000 kilowatts will be 40 percent of the reserve capacity of the hydropower system. After phase II is completed, the total generation capacity will be 1.5 million kilowatts and the Baishan station will assume 40 percent--305,000 kilowatts--of the system reserve. In the meantime, since the single generator capacity of the Baishan station is large (300,000 kW), they are especially important in serving as accident backup

for existing and future 300,000 kW and 500,000 kW large capacity thermal electric generators in the northeastern grid.

The northeastern region is relatively low on water power resources. Besides the mainstream of the Heilong Jiang, there are about 130 sites for building 10,000 kW or larger hydropower stations with a potential generation capacity of 9.59 million kW and an annual power production of 26 billion kilowatt-hours. Up to now, nine medium and large hydropower stations have been built with a combined generation capacity of 1.7 million kW, accounting for less than 20 percent of the exploitable water power. Together with the four hydropower stations currently under construction, the total generator capacity will be 3.69 million kW or 38.5 percent of the water power that can be developed. This shows the potential for future development and the prospects are even better if the development of the Heilong Jiang is also considered.

The large and medium hydropower stations currently under construction in the northeastern region include Baishan, Hongshi, Taipingwan, and Weiyuan. In addition, the Shuifeng expansion project at Changdian is also planned. The three stations at Baishan (phase I), Hongshi, and Taipingwan are expected to be completed around 1986. The associated departments should therefore continue their efforts of studying water power utilization in the northeast and do a good job in early phase work. In the meantime, the available construction force should be rationally used in hydropower construction on the upper course of the Di'er Songhua Jiang and in other regions. The important and urgent task facing us is to satisfy the development needs of the northeastern power grid and the four modernization.

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## HYDROPOWER

### GEZHOUBA'S CAPABILITY TO REGULATE PEAK LOADS

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 84 pp 42-43

[Article by Giu Fang [0093 0119] of the Gezhouba Water Conservancy and Power Generation Plant: "On the Participation of the Gezhouba Power Station in Power Network Peak Load Regulation"]

[Text] Issue No 3 of EDIAN KEPU ["Popularization of Electrical Sciences in Hubei"] contained an article by Comrade Zhang Yinggui [1728 5391 6311] entitled "On the Question of Peak Load Regulation by the Gezhouba Power Station." After reading the article, I felt that it stated the problem well and that it was very enlightening and beneficial. The question of whether or not the Gezhouba Power Station can regulate peak loads not only concerns energy conservation and safe and economical dispatching but also concerns to an even greater degree the safety of shipping on the Chang Jiang. It is an important question in production which urgently requires resolution.

On the basis of the questions proposed by Comrade Zhang Yinggui, this article will present some rough individual viewpoints from the perspective of the necessity and possibility of the participation of the Gezhouba Power Station in systematic peak load regulation during periods of non-dumping of water.

#### I. The Necessity of Peak Load Regulation by the Gezhouba Power Station

At present, the daily peak-to-valley load differential in the Central China Power Network is more than 1,200 MW, equal to about 20 percent of the maximum load. According to load predictions, the daily peak-to-valley load differential in the Central China Power Network will jump to about 2,700 MW by the end of the Sixth Five-Year Plan. There will be a corresponding increase in the hydropower generator sets suited to carrying the base load within the network following the continual installation and placing into operation of the generator sets at the Gezhouba Power Station. In order to adapt to peak load regulation capacity requirements, the power network not only must rely primarily on the Danjiangkou hydropower station to carry out peak load regulation, but also must still depend on small medium-temperature, medium-pressure generator sets and large capacity thermoelectric generator sets for peak load regulation. Despite this, the power network still feels that there is inadequate peak load regulation capacity and urgently hopes that the Gezhouba hydropower station will be able to engage in systematic peak load regulation as needed.

Hydropower station generators are easy to start and stop, can rapidly increase or decrease the load, and are able to adapt quickly to changes in the load curve. Moreover, peak load regulation by hydropower stations can lower fuel consumption in the system and improve system safety and economical regulation. For this reason, it is extremely necessary and urgent that the Gezhouba hydropower station be permitted to participate in systematic peak load regulation.

## II. The Possibility of Peak Load Regulation by the Gezhouba Hydropower Station

Apart from guaranteeing the minimum amount of discharge permitted by a certain shipping depth, hydropower stations also should maintain stability in water level changes above and below a power station according to the needs of shipping and to ensure the safe movement and berthing of ships. For this reason, the Gezhouba hydropower station design stipulated that it would be a runoff-type power station and could not engage in load regulation. If the needs of shipping can be met fairly well and the shipping and berthing safety of ships is not affected by peak load regulation, then it will be possible for the Gezhouba hydropower station to engage in peak load regulation. This possibility will be analyzed below.

### 1. Concerning the minimum amount of discharge permitted by a certain shipping depth

Based on the needs of shipping, the design stipulated that the minimum amount of discharge at the Gezhouba Power Station could not be less than 3,200 cubic meters per second. This is fairly easy to meet during actual operations. It is possible if the flow into the reservoir exceeds the minimum permissible discharge of 3,200 cubic meters per second and the power station valley load is limited, if a daily load curve has been compiled during the low-valley period when the water flow used for power generation is not less than the minimum permissible discharge and if operating personnel at the power station operate strictly according to the load chart. The power station does not have a reserve capacity if there is a breakdown in the operation of the generator sets. If the Erjiang sluice gate is quickly opened to supplement the water, the discharge will not be less than the minimum permissible amount.

### 2. On the question of change and stability in the water level upstream and downstream from the power station

In terms of the conditions required by changes in the water level of the reservoir and based on the needs of shipping, the design stipulates that the permissible range for changes in water levels in the Gezhouba reservoir is within 61 to 63 meters, between which there is a reservoir capacity of 123 million cubic meters. When the power station is regulating peak loads, the corresponding adjustment in reservoir capacity added to a certain moveable reservoir capacity as required by the peak-to-valley load differential should be less than the minimum permissible reservoir capacity corresponding

to the degree of change in the water level. According to estimates, if the Gezhouba hydropower station can regulate peak loads by 100 MW over a period of 3-4 hours, then the required adjustment in reservoir capacity is only 10 million cubic meters, equal to a change of only 0.3 meters in the water level. It can be seen from this that peak load regulation does not greatly influence the reservoir water level and that the needs of shipping can be met.

Looking at the conditions required for meeting the required changes in the water level downstream from the power station, apart from influencing vessels engaged in shipping, even more important is the effect on the berthing safety of ships about 7 kilometers downstream from the power station at Yichanggang. Generally speaking, the former will naturally be satisfied if the latter is. There can sometimes be accidents in the harbors if changes in the water level caused by peak load regulation reach or exceed a certain limit and the anchored ships and floating docks are not loosened in time. The amount of water flowing in the Chang Jiang varies through the year, and the amount even varies within a single day. Within these limits, the changes in water level can also be used for peak load regulation. If the Gezhouba Power Station regulates peak loads by 100 MW, and if it controls the discharge for power generation during low-valley periods at 3,200 cubic meters per second and only has a power generation discharge of 3,850 cubic meters per second for power generation during peak load periods, then the increased flow that will change the downstream water level will be only about 650 cubic meters per second. Taking into consideration regulation and storage in the river channel between the power station and Yichanggang, the water level at Yichanggang will only change by about 0.3 meters. This type of change in the water level will not affect Yichanggang. Through theoretical or experimental calculation of unstable downstream flows and experimental load regulation, and with close coordination with shipping departments, it will be possible to find a critical degree of change in water level which will not affect shipping and berthing safety at Yichanggang. When the power station is regulating peak loads, it will be possible to restrict the actual change in the water level from beginning to end to less than the critical degree of change in water level, to satisfy the need for changes in the water level downstream from the power station, and to guarantee shipping and docking safety at Yichanggang.

Looking at the above analysis and calculations, there is no problem at present in peak load regulation of 100 MW.

### III. Several Concrete Problems Which Should Be Considered for Peak Load Regulation by the Gezhouba Power Station

1. The electric power system should have a clear idea that peak load regulation by the Gezhouba Power Station should guarantee shipping safety. There must be strict observance and earnest implementation of the actual stipulations related to peak load regulation.

2. Based on the concrete operational conditions of the reservoir during each period, there should be a clear-cut stipulation of the least effort of the generator sets during low-valley periods corresponding to satisfying a certain permissible shipping depth with a minimum discharge of 3,200 cubic meters per second.

3. Clearly formulate the peak-to-valley load differential and peak load regulation calendar permitted for the Gezhouba Power Station and the changes in peak-to-valley loads according to the different amounts of flow into the reservoir. These changes are: 1) The power station will carry out normal regulation when the flow entering the reservoir to satisfy the stipulated peak-to-valley load differential also satisfies the low-valley smallest effort corresponding to a water usage of 3,200 cubic meters per second for power generation. 2) When the flow into the reservoir is reduced to the point where it is only able to satisfy the water usage for power generation of 3,200 cubic meters per second corresponding to the minimum effort in low valleys but cannot satisfy the stipulated peak-to-valley load differential, there should be a corresponding decrease in the peak-to-valley load differential originally stipulated for the power station in order to avoid power imbalances and to avoid replenishing the water in the reservoir and influencing its normal operation. When the flow into the reservoir is reduced to nearly 3,200 cubic meters, the Gezhouba Power Station is unable to regulate peak loads and must operate according to the base load. 3) When the flow into the reservoir increases to the point where the idling capacity of the generator sets is less than the peak load capacity, the peak-to-valley load differential of the power station should be reduced; when the flow into the reservoir increases to the point where the power station is dumping water, the power station should be operated to carry the base load.

#### IV. Conclusion

Based on the above analysis and knowledge, the author feels that peak load regulation by the Gezhouba Power Station under certain limited conditions is a real necessity as well as an objective possibility. From the point of view of the overall situation of construction of the Four Modernizations and development of science and technology, there should be active support of shipping, and the electric power system should adopt active but safe steps to carry out experiments and research related to peak load regulation in conjunction with support of and coordination with shipping departments. In order to achieve these results, the Gezhouba Power Station should be given a greater role in the Central China Power Network beginning in the period of no water dumping during the winter and spring and on into the future.

12539

CSO: 4013/113

## HYDROPOWER

### MINISTER QIAN SPEAKS AT WORKING CONFERENCE OF WATER RESOURCES AND HYDROPOWER DEVELOPMENT

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 84 pp 1-5

[Summary of Speech by Minister Qian Zhengyin [6929 2973 5391]: "We Must Reduce Construction Cost and Shorten Construction Time"]

[Text] In the first working conference held in 1982, after the establishment of the Water Conservancy and Hydroelectric Power General Company, I proposed that we should concentrate more effort on the construction of hydropower while completing our tasks in water conservancy construction. It was needed by the national economic development and expected of us by the Party Central Committee. In the last 2 years, under the leadership of the party committee of the General Company and as a result of the effort by all the water conservancy and hydropower workers, we have indeed achieved a great deal. In 1983 especially, the General Company suffered no loss and all the units forged forward and created the best prospects in recent years. In 2 years we have completed 2.747 billion yuan of capital construction, 35.9 million cubic meters of earthwork, poured 5.5 million cubic meters of concrete, installed 19 generators and produced 1.48 million kilowatts. All the priority construction projects have completed the state's plan ahead of schedule and the Hongshi, Taipingwan, Jinshuitan and Ankang projects have successfully stopped the flow [of their respective rivers]. The early phase work has made considerable progress and prepared 23 preliminary designs for 10.43 million kW. The early phase work of the national priority projects at Sanxia, Ertan, Longtan and Lijiaxia are all on schedule and have completed the survey and design task. The feasibility study reports on Sanxia and Ertan have been reviewed by the State Planning Commission. Major technical problems of projects under construction have obtained preliminary solutions which basically satisfied construction requirements. In the area of enterprise consolidation and manpower buildup, the General Company had six bureaus, plants and enterprises that were certified in 1983. The leadership of 28 units under the direct jurisdiction of the General Company has been readjusted and improved according to the "four modernizations" requirements and the political thought of the staff and workers has also been greatly enhanced. The improvement of management has also begun, the investment contract practice has been tested out in the Gezhouba and Jinshuitan projects and some progress has been made. The centralized management and speciality contracting system was tried in the Hongshi project and the results were satisfactory. The Lubuge, Tianshengqiao,

and Shaxikou projects are experimenting with making use of foreign capital and are moving forward actively. The economic responsibility system within the various construction units is also producing initial results. Good results have been obtained from the test point contract economic responsibility system with the geological survey team of the Design Institute. Compared to the situation right after the Revolution, our achievements are even more striking. We have built 23 million kW of hydroelectric power facilities and now rank sixth in the world. In 1983, a year with good water, we produced 86.5 billion kWh of hydroelectric power, which accounted for 24.6 percent of the total electric power output and exceeded the quota by 10 billion kWh. Hydroelectric output in 1983 saved 7 million tons of coal. But our achievements are still a long way from the goal of quadrupling the value of production and from the advanced world standard. The difference, in my opinion, lies in the task of "reducing the construction costs, selecting the best proposal and shortening the construction time" put forward for us by the leadership of the Party Central Committee. In this talk, I will discuss my understanding on the following three topics:

### I. Selecting the Best Proposal

The basis for reduced construction cost and shortened construction time is the selection of the optimum proposal. We must select the best proposal in our planning, layout, design and construction. We have many successful experiences in this area. For example, since the Revolution, construction projects have been successful when a river section is developed continuously in cascades. Gutian Xi, Maotiao He, Yili He, and Longxi He, Liujiaxia, Yanguoxia, Bapanxia, and Qingtongxia on the upper course of the Huang He, Xin'an Jiang and Fuchun Jiang, and Baishan and Hongshi on the Songhua Jiang are all developed in cascades. This experience also holds true in foreign countries. But in the past we often worked on one site and then switched to another and on the whole spent a lot of money without achieving very much. In the selection of design proposals, the pivotal position of Wujiangdu is a successful example. Many other selections are also good, such as the dam site selection at Panjiakou, but overall there are still many problems, among them:

1. Due to the lack of a general plan, it has been difficult to make a unified long-term deployment in design and construction. In some projects decisions were left hanging for a long period of time and in others action was taken hastily. The effects were that the construction crews were not given direction, the projects could not be streamlined, and construction sites could not be arranged.
2. Since there was not enough coordination between the geological workers and the hydraulic engineers, the survey methods were backward and the work volume was very large. Holes thousands of meters deep were not uncommon and the survey time was often very long. Even so, the plan often changed and problems were discovered even in the construction process.

3. Because of the long-term closed-door policy, the design standard fell behind the advanced world standard. We lack the experience in building concrete dams higher than 200 meters and we are especially inexperienced with tall earth dams. The design codes issued by the Ministry of Water Conservancy and Electric Power are often too conservative. The coefficient of friction used for concrete gravity dams is often lower than the value used by other countries and, as a result, the amount of work associated with hydraulic structures is increased. The obsolete design methods and the weak organization and management have also adversely affected the selection of the optimum proposal.

4. The 10-year turmoil disrupted people's ideology and the mutual mistrust between designers and construction engineers in some places has prevented the selection of the best plan. The design people were afraid that the construction workers could not guarantee the quality of their work and therefore increased the safety factor, the construction workers felt that the designs were conservative and thus paid even less attention to quality. These problems have also affected the selection of the best plan. The success of Wujiangdu stemmed from the close cooperation between the designers and the builders, but this problem remains unresolved at many other places.

## II. Reducing the Construction Cost

Ever since the Second Five-Year Plan, the cost per kilowatt in hydroelectric power has been on the rise. The investment per kilowatt has doubled from the Second Five-Year Plan to the Fifth Five-Year Plan. There are indeed objective reasons for the increase in cost, such as the increasing complexity of the construction, the rise in material cost, the increase in flood compensation in reservoir construction and pay raises for staff and workers. But subjectively there are also some problems, especially in the following three areas:

1. After 30 years we still have not learned the essence of mechanized construction.

We use machines in construction but we have not mechanized. The result has been the large increase in construction equipment with no reduction in the number of workers. The investment in the construction equipment is large, its percentage out of the total investment is increasing, but the utilization rate of the equipment is very low. The increase in the labor production rate has been slow and our present labor output does not compare favorably with other building enterprises in China. As the number of workers increases, the amount of temporary construction also increases and, coupled with seasons, the construction time is prolonged. The prolonged construction time in turn increases the construction costs. This is why I am saying that we have not really learned mechanized construction.

2. New technologies are not used well and the material consumption is high.

Some of the techniques proven effective in the past can no longer be called new techniques. For example, the "two additivites, three molds" method you people talked about cannot, in my opinion, be called a new technique, in that it was discussed in the 1977 conference. I browsed through the report

of Comrade Li Peng [2621 7719] in last year's working conference and found that he too talked about the "two additives, three molds" method and gave detailed specific discussions on using powdered coal ash as an additive. But up to now this technique still has not been widely adopted in our direct jurisdiction engineering bureaus. This technique is relevant to design as well as construction. Reducing the amount of cement consumption has an immediate effect on cost reduction, but we have not succeeded in doing so. Certain places were more successful than others, for example Engineering Bureau No 11 insisted on using powdered coal ash as an additive and Dahua also did a good job. But some of our big projects did not push this method. The technically more advanced Dahua for example, used an average of 170 kg of cement per cubic meter of concrete, whereas the Itaipu power station used only 135 kg of cement per cubic meter of concrete. We talked about the various objective reasons for high building costs such as increases in relocation compensation and material cost, but why can't we promote the use of powdered coal ash?—a product of this Ministry which we have total control of, as pointed out by Comrade Li Peng in last year's meeting. This problem must be resolved.

### 3. Backward management.

This question has been addressed in detail in the work report of the General Company. I think the problems are the practice of eating out of the big pot and taking advantage of the big consumers. Every year we lose considerable money because of these two problems. Here I must first confess to you that this Ministry took advantage of the big energy consumers among you in the 1983 meeting. The Ministry of Water Conservancy and Electric Power holds numerous meetings in Gezhouba and some of the costs of running these meetings and the costs of meals are imposed on you. The Ministry is taking advantage of the big energy consumers! We will now make an announcement: five things are forbidden when the Ministry holds meetings, and one of them is that the meeting expenses cannot be imposed on the basic units. I ask you to keep an eye on this and please boycott and criticize whichever department that violates this rule, including mine.

### III. Shortening the Construction Time

We shall make two comparisons here, one is a comparison between the three large and medium construction projects currently underway with foreign projects. The Longyangxia power station began its construction in 1976 and is expected to be completed in 1989, the construction to take 12 years. The Baishan power station began its construction in 1971 and is scheduled for completion in 1986, the construction to take 15 years. The Tianshengqiao power station began its construction in 1981 and will be completed in 1993, taking 12 years. If we take the construction time to be from the beginning of the construction to the time when the first generator produces electricity, then the Longyangxia power station will begin producing electric power in 1986 and the construction time will be 10 years. The Baishan power station will start producing electricity in 1983 and the construction time is 12 years. The Tianshengqiao power station is scheduled to produce electricity in 1990 and the construction time will be 9 years. In foreign countries,

the 1.21 million kW Furnas power station in Brazil has a construction time of 5 years, the 2.1 million kW (Idubeila) power station has a construction time of 6 years and even a large power station such as the 12.6 million kW Itaipu has a construction time of only 7 years. The second comparison is with the large and medium hydropower stations built in the last 1950's and the early 1960's. The Xin'an Jiang power station was built in 8 years from 1957 to 1965. Its first generator began producing electricity only 3 years after the construction began. The Tuoxi power station was built in 5 years from 1958 to 1963 and its first generator began operation in 1962, only 4 years from the start of construction. But today the construction times are much longer. Are there any construction problems besides insufficient investment and design problems? I think we should look at the following two areas:

The first problem is that the construction of hydropower stations takes too long on both ends, that is, preparation takes too long and completion takes too long. The construction time for the main body actually is not very long. First of all the preparation work for the construction has increased considerably. Some of the preparation is not really for the construction of the main body, the increase is caused by the extensive construction of temporary housing. As the equipments increased, the number of workers did not decrease, in fact, the number has increased a lot and more houses must be built. The construction of the large number of temporary housing increased the statistical data, the investment in the preparation work in the past was less than 10 percent of the total investment, but now it is more than 15 percent and in some cases as high as 20 percent. This increased work volume naturally prolonged the time. The construction preparation time used to be a year or so, and now it is 3 years. The projects also took too long to finish at the end. The objective causes include shortfall in funding which causes gaps in construction. But there are subjective reasons as well. The Bikou, Gongzui and Fengtan power stations began full-scale power production in 1977, 1978, and 1979 respectively and yet they are still not finished. Of course there are good examples too, for instance, the Taipingshao power station and the Wujiangdu power station took only 2-3 years from power production by the first generator to completion and certification. This shows that the overall construction time can be greatly shortened by paying more attention to the last phase work.

The second problem is that in many ways we have not really mastered the method of scientific construction and the relationships between the main body and the auxiliary, between progress schedule and quality, between quantity and image and between priority and balanced organization. All these relationships must be handled scientifically. We often tried to move fast in our construction projects but ended up progressing very slowly. In many cases we have hastily laid foundations, rushed to pour the first cubic meter of concrete poured in 1 year. As a result, we disrupted the construction sequence and not only hampered progress but prolonged construction time due to quality problems. This kind of superficial and unrealistic approach remains a problem even today.

So far I have only expressed some personal views on the three areas pointed out by the leading comrades of the Party Central Committee. I did not attempt to cover everything in depth, instead, my intention was to further the

discussion. The responsibility of the problems I just discussed should in many cases belong to the leadership of this Ministry and especially myself. I urge you to express your opinions, raise your awareness and improve our work. I also hope that various units look for subjective and internal problems in addition to objective and external causes. Reaching the goal of quadrupling the output in hydroelectric power naturally needs more investment, but the situation will not improve even with more investment if the problems we just discussed remain unresolved. As pointed out by the Party Central Committee, "What if we built three power stations with the money for two, or four power stations with the money for three, isn't that equivalent to saving one-third or one-fourth of the investment?" I believe this comment by the leadership of the Party Central Committee has really hit the nail on the head. We do have this potential and the key is that we do a good job in the "phase II" work.

The key to the "phase II" work is basically building a modern socialist construction work force and the key to building a good team is to strengthen our leadership so that the leaders at the various levels can assume the heavy responsibility for modern socialist construction. This was also expressed by the Party Central Committee in its letter, "We believe that you do have such capable and talented people and your trust in and support for them have created impressive achievements." The capable and talented people are among you in the audience and you are the present and future leaders.

I would also like to mention here that the Party Central Committee asked us to learn from the experience of diverting the Luan He and posed the question: "Can the electric power workers come up with two or three more such examples in the next few years?" (It was referring to new construction and not completed work in the past). How should we interpret this question? I noticed that some briefings in this meeting suggested that we create an example in some future construction, which is not my understanding of the question. My understanding is that we should not only create examples in future projects, we should first create examples in construction currently underway. Every construction project we now have has the potential of becoming an example and every unit can become an example by making achievements in their learning from the Luan He diversion experience.

In order to do a good job on the "phase II" work, I hope that the leaders of the various units can achieve the following three things:

- (1) Be aware of the global situation of socialist construction.

I believe that no good work can be done without such awareness. In the global situation there are always major roles, supporting roles, offense, defense, first battle, second battle, and third battle. Based on the state's needs, we will have a certain strategy in our future construction efforts in water conservancy and hydroelectric power. All our design institutes hope the project they design can begin first and all our engineering bureaus want to be assigned a major project. This mentality is entirely understandable. But in the national plan there will always be priorities and emphasize. In this regard the proper question to ask is how to make active contributions with what we have. For this reason, I especially admire the achievements made by

Engineering Bureau No 11 under difficult circumstances. Today most of the hydropower stations started in the 1970's are in the stage of machine installation and we have the urgent need to start a second batch of hydropower stations. How do we make the choice? Which station should we work on after the Longyangxia power station on the Huang He? What about the Chang Jiang? The plan for the year 2000 needs all the power stations but there must be an order. The order must be decided based on the overall consideration of the national economic construction and the nation's energy resources and transportation capacity. No matter what the decision will be, we must look at the problem from a global viewpoint and not with tunnel vision. We must treat water conservancy and hydropower as the business of our entire team and our goal is to develop water conservancy and hydroelectric power in the whole nation. As long as we are aware of the global situation of the socialist construction, we can learn from the Luan He diversion example in our own units and make the greatest possible contribution.

## (2) Facing up to the modernization standard

Since our goal is to establish a modern force for the socialist construction, the leadership of every unit should study the modern standard their unit should reach. The leaders should be aware of the modern standards in survey, design and construction. Even though our present conditions do not meet the modern standards, we should be clearly aware of the direction we must move toward and we should not be content with the status quo and muddle along without change. Only with the correct goal can we set the correct policy and guideline. For example, we often have tens of thousands of workers on our construction sites, this is definitely not the modern standard. In foreign countries a large construction site has only a few hundred or up to a thousand workers. This problem of course cannot be resolved as yet, but we should know what is the correct direction. Should we let the construction crew swell to a larger size or should we gradually solve this problem? The direction we take affects our practice and determination. We should move toward reducing the number of workers when we plan our energy base, initiate our new construction projects and study our policies. In this area, to my knowledge, the successful unit is again Engineering Bureau No 11. This bureau is based on Sanmenxia but their construction site is in Guxian, quite a distance away. They have set down some rules to encourage the workers to live at the construction site alone, leaving dependents behind. This way, they were able to keep a lean force at the site and the housing problems were simplified. Without such a rule, the dependents of the workers would come along and there would again be extensive building of dormitories at the new site. If our leaders do not face up to the modern standard in our construction of a modern team, then our efforts will be aimless and modernization will become empty rhetoric. The engineering bureau and the survey and design institutes all face the same problem. Our leaders should also have some direction in mind for the future effort of our survey teams.

## (3) Setting short-term goals

As the old saying goes, a journey of thousand miles begins with the first step. We must first decide what needs to be done in this year and in next year in a long-term effort. Without near-term objectives and specific tasks,

the long-term effort cannot begin. This time the General Company listed 18 questions for discussion and you have all actively participated. I think they were all good questions but would like them to be more specific in pointing out near-term goals and objectives.

We hope that every unit would study the modern standards that are necessary for them to choose the best proposals, lower the cost and shorten the construction time. Each unit should identify the internal problems that need be solved now and then report to the General Company on the specific tasks for the next few years, especially this year. We also ask the General Company to write a report on the discussion results of this meeting and we will forward this report to the Party Central Committee. We must provide ourselves with the pressure necessary to produce results. The leaders are supposed to lead the masses forward and good leaders are not afraid of setting goals for the masses and are good at leading the masses forward in big strides.

Finally, I believe there are many capable and talented people in our ranks. We are totally behind you in making admirable achievements for the water conservancy and hydroelectric power industry and for the "four modernizations" construction.

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CSO: 4013/162

## HYDROPOWER

### PRELIMINARY PLANS FOR YANTAN APPRAISED

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 2, 12 Feb 84 p 51

[Article by Sun Yaozeng [1327 5069 1073]: "Preliminary Plan for Yantan Hydropower Station Appraised"]

[Text] Under direction of the State Planning Commission, a meeting to appraise the preliminary plan for the Hongshui He Yantan Hydropower Station was held in Nanning from 9-16 September 1983 with participation by the Ministry of Water Resources and Electric Power, the Guangxi Zhuang Autonomous Region, and other related departments. Specialists, professors, and engineering and technical personnel from Qinghua University, the Ministry of Geology and Mineral Resources, and the Geological Research Institute of the Chinese Academy of Sciences were also invited to the meeting. After listening to reports, making on-the-spot surveys and holding group discussions, the conference felt that the Guangxi Electric Power Bureau Survey and Design Academy had done a great deal of work and that the proposed achievements basically suited preliminary design requirements. The conference basically agreed with the revisions of the preliminary design for the Yantan Hydropower Station proposed by the Guangxi Academy and the pivotal overall arrangements and organizational plans for construction that were made by the Bureau of Water Conservancy and Hydropower Construction and the Planning and Design Academy in April-June 1983, and examined the overall budget estimates, the plans for moving people from the reservoir area and other special topics. The comrades at the meeting felt that the Yantan Hydropower Station should be made a project for development in the near future according to the plans for the Hongshui He that were approved by the State Council. The construction conditions are now mature, and based on the needs of electrical power development in the South China region, the power station will be included in 1984 state plans and construction will formally begin.

12539

CSO: 4013/113

## HYDROPOWER

### SECOND BAISHAN GENERATOR NOW OPERATIONAL

OW081312 Beijing XINHUA in English 1154 GMT 8 Jul 84

[Text] Changchun, 8 Jun (XINHUA)--China's industrial northeast is getting more power supply as the second 300-megawatt generating unit of the region's largest power station went on line this morning with the regional power grid.

Construction of the Baishan hydroelectric power station on the Di'er Songhua Jiang, the main tributary of the region's major waterway, the Songhua, is being undertaken in two stages. The first-stage construction started in 1975, involving the installation of three 300-megawatt generating units. The first of these went into operation at the end of last year.

Baishan is designed for five such generating units, giving an annual power output of 2 billion kWh, and increasing the existing peak-load generating capacity of northeast China by 30 percent.

Baishan is 250 kilometers upstream from the Fengman hydroelectric power station, the first built on the Di'er Songhua Jiang. Another hydroelectric power station is under construction at Hongshi, between Baishan and Fengman.

A major industrial base of the country, northeast China may count on these power stations for more power supply. The region produces a significant amount of the country's iron and steel, nonferrous metals, machinery, petroleum, chemical products, and paper. Large backbone enterprises include the country's largest iron and steel producer, Anshan, the largest oil producer, Daqing, the Changchun No 1 Motor Vehicle Plant, the Jilin Chemical Industrial Corporation, and the Hulan Heavy Machinery Plant.

CSO: 4010/113

## HYDROPOWER

### JAPANESE FIRM WINS LUBUGE TUNNEL CONTRACT

OW161422 Beijing XINHUA in English 1151 GMT 16 Jul 84

[Text] Kunming, 16 Jul (XINHUA)--The Taisei Corporation of Japan has won a contract to build a 9-kilometer tunnel for key hydroelectric power station at Lubuge on the Huangni He in southwest China.

The Japanese engineering and construction company signed a contract on the project with the Lubuge Engineering Administration under the Ministry of Water Resources and Electric Power on Saturday.

Under the contract, the firm will send technical personnel next month to Lubuge, more than 370 kilometers from Kunming, capital of Yunnan Province.

The 600,000-kilowatt Lubuge hydroelectric power station will be built on the Huangni He along the border of Yunnan and Guizhou provinces.

Bidding for the contract opened last November in Beijing. Representatives from eight companies in Japan, France, Italy, the Federal Republic of Germany, Yugoslavia and China competed.

Scheduled for completion in 1989, the station will produce 2.9 billion kilowatt-hours of electricity a year. It is being built with a World Bank loan of 150 million U.S. dollars.

The project consists of a dam across the Huangni He, a tunnel, and a power house.

CSO: 4010/114

## HYDROPOWER

### HARNESSING WATER RESOURCES IS KEYSTONE OF SICHUAN POWER PLANS

Chengdu SICHUAN RIBAO in Chinese 25 Jun 84 p 2

/Article by Wang Zunxiang /3769 1415 4161//

/Text/ By the year 2000, the annual industrial and agricultural production of Sichuan Province will be tripled, and the electric power demand will increase by a factor of 6.57 to 114 billion kWh. Therefore, in order to increase the people's wealth and the relative ranking of Sichuan Province, it is essential to develop its electric power.

Leaders of the central government recently proclaimed: "The southwest region not only will be the fastest-growing and the largest energy base in China, its development will require little investment and produce a minimum amount of pollution." The implication of this directive is that the fundamental approach to developing Sichuan's electric power is to exploit the potential of Sichuan's water energy resources.

Sichuan Province is blessed with criss-crossing mountain ranges, abundant rainfall, many rivers and highly developed waterways. There are more than 1,300 rivers in the province. The total volume of water including rivers passing through the province amounts to approximately 450 billion cubic meters, which is 9 times the volume of China's largest river--Huang He. The water energy reserve in the province ranks second in the country; the potential power generation capacity is 9.68 million kW, the annual power generation can reach 515.3 billion kWh, which ranks first in the country. This amount of electric energy is equivalent to 62 billion tons of coal reserve and an annual coal production of 310 million tons; but it is a renewable energy resource.

The geographical distribution of hydraulic resources and coal reserves in the province are complementary to one another. The eastern part and inland region of the province are mostly small hills and plains, with few water resources and moderate river drops; they are suitable for constructing medium size hydropower stations. But these regions, which include the northeast and the southern part of Sichuan, are rich in coal reserves and hence are suitable for developing coal-fired electric power. The western part of the province is characterized by numerous mountains and valleys and an abundant water supply from steady rivers and

large drops; it is the richest region in hydropower in Sichuan Province, or perhaps in the whole country. In particular, the water energy resources from the Jinsha Jiang, Yalong Jiang, and Dadu He contain two-thirds of the potential power generation capacity of the entire province, which is approximately three times the capacity of the Huang He. This region is also suitable for constructing large dams without suffering excessive flood loss; consequently, it requires relatively little investment and is expected to produce a large payoff and achieve high economic returns. It is particularly fortunate that this is also one of the regions which has the richest mineral resources and natural resources in Sichuan and in China; it has now developed into a base of China's metallurgical industry. The combination of energy and mineral resources is another great asset of Sichuan Province, providing a foundation for increasing the people's wealth and the relative ranking of the province.

However, in spite of the rich energy resources in this province, the rate of utilization of hydropower is very low. Up to 1983, the total generator capacity of all the hydropower stations in Sichuan amounted to approximately 2.31 million kW, which was only 2.5 percent of the available capacity, and the annual power generation was 8.94 billion kWh, which was only 1.7 percent of the potential power generation, both below rational standards. Failure to exploit the water energy resources in the province is like dumping 300 million tons of prime coal into the ocean every year; it is a shame that so much resources are wasted!

To exploit the water energy resources, we must concentrate our efforts on hydroelectric power construction. Through the development of hydroelectric power, we will be able to change the backward status of the electric power industry and create a new era for electric power construction.

However, in developing and exploiting the water energy resources in Sichuan Province, we must also consider the needs and interests of the national economy. In other words, the problem of electric power shortage in the province should be considered as part of the problem of electric power shortage of the whole country.

Following this guideline and supported by the leaders of Yunnan, Guizhou and Sichuan Provinces, we formed a team with the electric power departments of Yunnan and Guizhou Provinces. After sponsoring many discussions and studies by experts in the field, we established a plan "to deliver electricity from west to east," which was designed to make maximum use of water energy resources. According to this plan, we shall develop the rich water energy resources of the southwest into electric power which will be transmitted to the southern and eastern parts of China through ultra-high-voltage networks. To implement this plan, it is required that during the 20 years from 1980 to 2000, Sichuan Province must develop the water energy resources of the Yalong Jiang, Dadu He, Wu Jiang, Bailong Jiang, and Min Jiang, and begin construction of 15 hydropower stations with a total generator capacity of 18.35 million kW,

eight of which will be completed with a total production capacity of 8.73 million kW. In the area of coal-fired electric power, the Junlian and Furong coal mines will be developed, and a southern Sichuan coal-fired electric power base will be established; furthermore, the Chongqing, Baima, and Jiangyou power plants will be expanded to provide a generator capacity of 5.2 million kW, with 5 million kW in actual production. Both hydro and coal-fired electric power will be developed in four stages in accordance with the 6th, 7th, 8th, and 9th 5-year plans.

The conditions for carrying out this plan are already in place. In terms of material resources, we have unparalleled water energy resources and abundant coal resources. The central government has established favorable policies by announcing the decision to accelerate the development of the southwestern region and increasing the priority of energy construction. Progress has already been made in the initial phase of electric power construction; preliminary design reports and feasibility study reports have been completed; four hydropower and coal-fired electric power construction projects have begun; another large hydropower project will begin in the second half of this year. The design and assembly tasks are facilitated by the fact that three major factories which build boilers and turbines for large coal-fired electric power plants and hydraulic turbine generators are all located in this province.

The exploitation of Sichuan's water energy resources, the active development of medium and small rivers, and the construction of medium and small hydropower stations are all of great importance. The potential capacity of small-scale hydropower in the province is approximately 5.1 million kW. Up to last year, the construction of 970,000 kW had been completed, and 350,000 kW has been connected to the national grid. These small hydropower stations have played an important role in stimulating the overall economy, particularly the economy of farm villages of the province. Small hydropower projects have certain advantages such as smaller scale, less investment, shorter project duration, and more immediate return. In the future, in conjunction with the construction of major hydropower stations, we must try to mobilize the necessary manpower and collect sufficient funds to develop small hydropower. We must also carry out the policies of "self-construction, self-management, self-utilization," and "develop electric power through electric power." In particular, special efforts should be devoted to the development of minority regions, mountainous regions and economically poor regions located in the northern, eastern and western parts of the province in order to promote the material and spiritual construction in these areas. The electric power departments should do their best to support these efforts.

Emphasis on the exploitation of hydropower does not mean ignoring other energy resources. As long as technology and economic conditions permit, we should strive to develop other energy resources such as wind energy, solar energy and marsh gas. These will provide the supplementary energy sources necessary to eliminate the energy shortage in Sichuan Province.

## HYDROPOWER

### BRIEFS

SECOND DAHUA UNIT PRODUCING POWER--Nanning, 28 Jun (XINHUA)--A hydroelectric generator with a capacity of 100,000 kilowatts went into operation on Wednesday at one of a series of power stations being built on the Hongshui He in Guangxi Zhuang Autonomous Region. The generator is the second unit of the Dahua hydroelectric power station, which will ultimately have a generating capacity of 600,000 kilowatts. The first unit of the same capacity went into operation at the end of last year. The third and fourth units are being fitted out and are expected to be completed early next year. By the end of the century, ten hydropower stations will have been built on the Hongshui He, with a combined generating capacity of 12 million kilowatts. [Text] [OW291518 Beijing XINHUA in English 0855 GMT 28 Jun 84 OW]

CSO: 4010/113

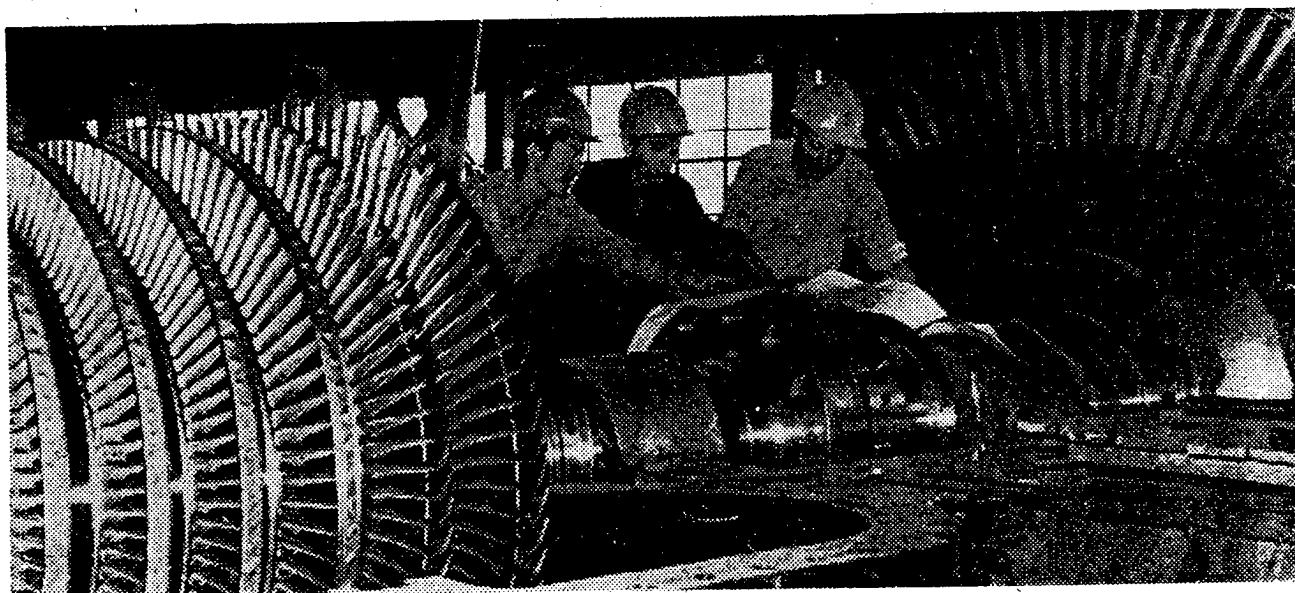
## THERMAL POWER

### PHOTOGRAPHS DEPICT PROGRESS AT SHENTOU POWER PLANT

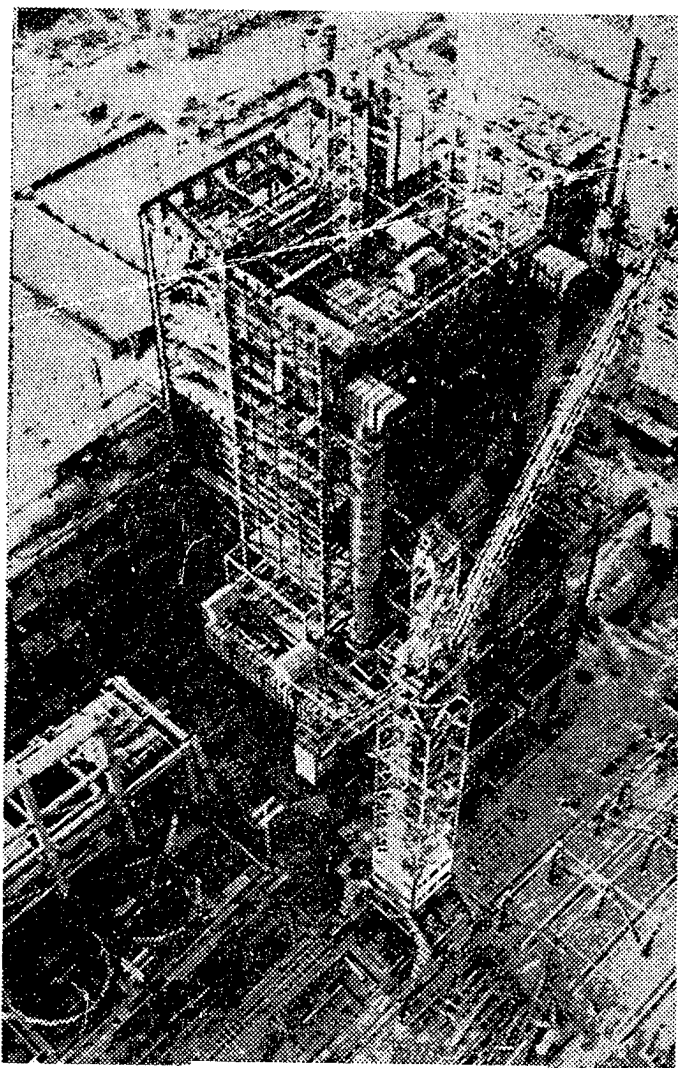
Beijing RENMIN RIBAO in Chinese 5 Aug 84 p 8

[Summary] One of the nation's major construction projects, the Shentou power plant is also the largest pit-mouth power plant in China today. In the first stage, the installed capacity was 150,000 kilowatts, expanded to 400,000 kilowatts in the second stage. The third-stage construction is slated for completion in 1985.

Installed capacity in the third stage will be 800,000 kilowatts and following completion, power is to be transmitted to Beijing, Tianjin, and Tangshan. The project is being handled by the Shaxi No 2 Electric Power Construction Company, an outfit known for its high level of mechanization and quality work.



Chinese technicians install main machinery with Czech expert providing direction.



Thousands of tons of steel materials go into this boiler of the third stage construction.

CSO: 4013/210

## THERMAL POWER

### BRIEFS

NEW DATONG GENERATING UNIT--Taiyuan, 30 Jun (XINHUA)--A 200,000-kilowatt generating unit went into operation in Datong, Shanxi Province, today. This is the first generating unit in the Datong No 2 power plant, a top-priority construction project designed to provide Beijing with electricity. A 280-kilometer, 500,000-volt power transmission line between Datong and China's capital was erected on 29 May. The plant, which will have six generating units with a total capacity of 1.2 million kilowatts by 1990, will produce 8 billion kilowatt-hours of electricity annually. Another 200,000-kilowatt generating unit is to go into operation in the first quarter of 1985. [Text] [OW301640 Beijing XINHUA in English 1630 GMT 30 Jun 84 OW]

BANSHAN ADDS 125MW UNIT--At 5:08 pm yesterday, the No 4 generator unit at Hangzhou's Banshan Power Plant--a major construction project for Zhejiang Province--began feeding power into the grid. This generator has a capacity of 125,000 kilowatts, making it one of the province's biggest thermal power units. It is capable of generating 800 million kilowatt-hours of electricity a year. [Text] [Hangzhou ZHEJIANG RIBAO in Chinese 1 Jul 84 p 1]

CSO: 4013/197

## COAL

### TRENDS IN SURFACE MINING TECHNOLOGY IN CHINA

Beijing MEITAN KEXUE JISHU [COAL SCIENCE AND TECHNOLOGY] in Chinese No 5, May 84 pp 34-41

[Article by Shi Yuqian [2514 5940 6197] and Fan Qiwen [5400 1142 2429]: "An Inquiry into the Direction of Technological Development in China's Surface Coal Mines"]

[Text] Coal makes up more than 70 percent of China's energy structure. It is estimated that coal output in China will increase to 1.2 billion tons by the year 2000. Of this amount, a net increase of 200 million tons will come from surface coal mines, equal to 28 percent of unified distribution coal output and one-half of the design capacity of the newly constructed coal mines.

China has abundant coal resources. There are several large or very large coal fields in the north, northeast and southwest of China that are suited to surface extraction. If the external transport conditions and internal conditions (referring to the degree of prospecting), reserves, technical levels and other matters are mature, then large-scale surface extraction can be carried out rapidly in these coal fields. This can alleviate energy shortages.

Many years of experience at home and abroad has shown that the development of surface extraction is an important route for substantially increasing coal production. This is determined by such characteristics as high output, fast construction, high work efficiency, safe production, and good labor conditions. To assure continuous and stable increases in coal production in China, the direction for energy development should be the substantial development of surface coal mining (including rebuilding and expansion of currently producing surface coal mines). There will be a net increase of 200 million tons of coal from surface extraction in China by the year 2000. With an extraction ratio of 4 m<sup>3</sup>/t, then apart from producing 200 million tons of coal annually, an additional 800 million m<sup>3</sup> (about 1.6 to 2.0 billion tons) of rock and earth also will have to be extracted. The need to move such a large amount of material not only necessitates urgent scientific research, design, and production management work, but also requires us to develop equipment series suited to China's mine conditions as quickly as

possible, and to attain the corresponding extraction techniques through the close cooperation of all industrial departments, under unified planning, with domestic trial manufacture, cooperative manufacture and other forms. Only then will we be able to guarantee the stable and positive development of surface coal mining in China. In order to meet the coal needs of the entire national economy and to increase output as quickly as possible, we must accelerate the construction of a number of new surface coal mines. Their development must be built firmly on the basis of scientific and technical advances. Two steps are required to attain the goal of a net increase of 200 million tons: The first step, during the first 10 years (1984 to 1993), is to use the large-scale surface equipment already being manufactured in China or to import part of the equipment from abroad to construct a number of surface coal mines of various types with a total annual extraction amount of 400 to 500 million  $m^3$  (equivalent to an annual production capacity of 100 million tons of coal). The second step, during the final 7 years, is to build a group of major surface coal mines. This article will use a macro viewpoint to discuss some of the problems that may be encountered in new construction or reconstruction during the first 10 years.

#### I. The Scale of Production (Type of Mine) and Service Period of Surface Coal Mines

The production scale of a surface coal mine refers to the total amount of earth and coal extracted annually from the mine. The production scale of surface coal mines is larger than metallic or other non-metallic surface mines, as is the area they cover. Apart from differences in coal output compared to shaft coal mines, even more important is that the extraction ratio in surface coal mines determines the amount extracted. The latter has a major influence on investments, costs, work efficiency and other major technical and economic indicators.

The development of extraction technology equipment and the centralization of production over the past 20 years have changed the concept of the production scale of surface coal mines. Formerly large-scale mines are now seen as medium-sized ones. The production scale of surface coal mines and the years of service are shown in the table below, based on annual total amount extracted and annual coal output indicators, and on the forms of technology and types of equipment that can be used.

We now will provide some examples from abroad of the production scale of surface coal mines.

The Soviet Union's (Yongshi) surface coal mine has an annual design capacity of 50 million tons. The extraction ratio during the early period was about  $1.2 m^3/t$ , and total annual extraction was about 100 million  $m^3$ , meaning that it was a Type IV surface coal mine. West Germany's Hammbach [?] surface lignite mine has an annual production capacity of 50 million tons, an extraction ratio of about  $3.5 m^3/t$ , and an annual total extraction amount of about 200 million  $m$ , which means

that it is a Type IV surface coal mine. Annual production capacity at China's Fushunxi surface coal mine is 2.6 to 5.6 million tons. Total annual extraction during peak flooding periods is about 4,000 m<sup>3</sup> [as published], and it is a Type III surface coal mine. The Haizhou surface coal mine at Fuxin in China has an annual production capacity of 3.00 to 4.80 million tons, and total extraction during peak flood periods is about 30 million m<sup>3</sup>. It is a Type II surface coal mine.

#### Scale of Production and Service Period of Surface Coal Mines

<u>Item</u>	<u>Scale of Production (Mine Type)</u>			
	<u>Type I</u>	<u>Type II</u>	<u>Type III</u>	<u>Type IV</u>
Annual total amount extracted (million m <sup>3</sup> )	20	20-40	40-60	60
Annual raw coal output (million tons)	4	4-8	8-12	12
Technological patterns and equipment	Single bucket loader + truck (or rail), collapsing extraction	As at left, with slightly larger models of equipment	Semi-continuous, continuous or segmented integrated extraction	As at left, with slightly larger models of equipment
Service period (years)	20	25	30	35

(Note: The classification of mine types is based on a single comparable standard of annual total amount extracted or total annual coal output)

The classification of the scale of surface coal mine production has two meanings. One is technological feasibility; the other is economic rationality. Mine types and system indicators based on technological feasibility make use of existing domestic and foreign technical mining equipment for extraction, and can attain the upper limits of total amounts extracted. Mine types and system indicators based on economic rationality can determine which production scale has the lowest production costs or greatest profits. Economic research on the latter has just begun in China, although more research has been done in America, the Soviet Union, Canada, and other nations. Some have already reached the quantitative stage. Generally speaking, production costs are lower the larger a mine is (although not infinitely large) because the proportion in fixed assets is inversely related to the type of

surface coal mine (statistical analysis of the amount of investments in the commonly used part such as industrial construction, public services facilities, mine region road construction, hydroelectric construction, communications lines, and so on, can be based on the concrete conditions of a mine). Therefore, whenever the area, reserves, investments and equipment supplies in a surface coal field permit extraction, we should strive to adopt a fairly large mine type and achieve centralized production. This is economically feasible.

In order to guarantee that more coal can be extracted during the first decade, we should build a group of Type I and II surface coal mines based on China's actual conditions. With this foundation, they can be rebuilt or expanded into Type III or Type IV surface coal mines.

## II. Techniques and Equipment

The small scale and simplicity of China's existing technical equipment is an important barrier to the development of large scale surface coal mines. We should, therefore, act to guarantee the development of surface coal mining as quickly as possible by forming an industrial equipment system that is suited to extraction in each type of surface coal mine in China.

We should select the appropriate type of technical equipment for each type of surface coal mine according to the geological and climatic conditions of a coal field so that each type of equipment can be used to advantage and in the proper place. It is inappropriate and uneconomical to use a single type of technical equipment for extraction in surface coal mines with different conditions. The construction of surface coal mines with many different types of mineral qualities must be done according to a divided circulation system, that is, integrated extraction, before the total amount extracted can be increased. What types of technical equipment should China develop? The primary areas are listed below:

### 1. Continuous technical equipment

Continuous technical equipment is primarily suited for use in the extraction of fairly soft capping layers in large-scale surface lignite mines and in layered extraction techniques for improvement of coal quality. There are two types of technical equipment of this sort: One type is a rotary bucket loader + conveyor belt + bulldozer; another type is a rotary bucket loader and chain bucket loader + earthmoving bridge (transport and dumping equipment). The first system can be divided into four types according to the theoretical hourly capacity; small scale ( $630 \text{ m}^3/\text{h}$ ), medium scale ( $630\text{--}2,500 \text{ m}^3/\text{h}$ ), large scale ( $2,500\text{--}5,000 \text{ m}^3/\text{h}$ ) and extra large scale ( $5,000$  to  $10,000 \text{ m}^3/\text{h}$  and over). Industrial experimentation on the small-scale set has already been done at the Maoming surface mine in Guangdong Province, and it was appraised by the state in 1979. Work on medium-scale sets is now being carried out at the Xiaolongtan surface mine in Yunnan Province. China has not yet begun to develop large-scale and extra large-scale sets, and can consider importing the appropriate equipment or carrying out cooperative manufacture.

In the next 10 years, we should become involved in the development or importation of large- and medium-scale continuous technology equipment sets with a capacity of around 3,000 to 5,000 m<sup>3</sup>/h and medium-level cutting capacity (8-14 kg/cm), or higher capacity sets with lower cutting capacity. If the next annual working time of these sets is at least 4,000 hours (the minimum level), then each piece of equipment can excavate more than 20 million m<sup>3</sup> of rock and earth annually. This will provide mining equipment with a high volume of extraction for the construction of large-scale surface mines in China. In order to give play to the superior extraction volume of this large-scale equipment in our country, we must complete work in the following areas in advance or at least concurrently:

- 1) Operations, maintenance and administrative technicians should undergo formal vocational training and pass strict examinations before they are allowed to take up their jobs. An example is the (Naiweili) surface mine in India which imported continuous technology equipment from West Germany. One-third of the operations and administrative personnel went abroad for special training. The equipment is being operated very well now.
- 2) We must depend on domestic supplies for quick-wearing parts (such as bucket teeth). Parts development must be done concurrently with importation of the primary equipment. In the past, much imported equipment could not be operated for long periods. The lack of an ability to manufacture and supply the necessary parts was a major reason for this.
- 3) The hard interbedded waste rock or frozen earth layers within the rock strata and coal seams is an important factor that has caused a decline in the productive capacity of rotary bucket loaders. For this reason, we should begin now to develop the related scarifying machinery and drills. Excellent blasting qualities of the rock and soil mean, that there is a wider scope for the use of rotary bucket loaders suited to slightly harder rock or coal, and that this is an important means for improving their production capacity.
- 4) Develop or import as quickly as possible the auxiliary equipment for the primary machinery in continuous technology equipment, such as the moving equipment of rubber belt noses, scattered material collectors, vulcanizers, machinery used in road construction, and so on. Auxiliary equipment is an important guarantee for improving the utilization rate of the primary machinery. The Soviet Union's Ministry of Coal Industry has now given equal emphasis to the manufacture of auxiliary equipment and to primary machinery. For example, the Soviet Union is using a Model ERSRD-5000 continuous technology equipment set (the capacity is 5000 m<sup>3</sup>/h when extracting coal) that has been manufactured for more than 20 years. Because the auxiliary equipment was not fitted well, the utilization rate of the primary machinery was fairly low, with an annual capacity of about 10 million m<sup>3</sup>. The advantages of its large capacity have not been fully made use of (the lowest annual capacity is 20

million m<sup>3</sup>). Another example is the Model TK2 continuous technical equipment made in Czechoslovakia (capacity 5,000 m<sup>3</sup>/h). A small pulverizer was installed on the material collection side of the rotary bucket dumper, and they also installed a pulverizer on the material collector arm, thus preventing or reducing the effect of large chunks of rock on the rubber belt and greatly improving the utilization rate of the primary machinery.

5) The adoption of a seasonal working system in stripping engineering to make use of the coldest time of the year (in the north) to shut down the machinery for repair. This makes it possible to avoid the working conditions and environments that make it most difficult to use continuous technology equipment. Rubber belts are the main parts of this equipment. Although the technology for maintaining normal operation in temperate zones is already mature, there have been no breakthroughs in rubber belt technologies under extremely cold conditions. Moreover, the part having the greatest stress in continuous technology equipment is made of cold-tolerant fine grain steel powder. There is still a danger of breakage due to brittleness when the normal temperature is less than -25°C. Therefore, its use is most appropriate in seasonal work systems. In order to maintain equilibrium in coal extraction, stripping engineering should maintain a certain amount of lead time.

The use of a second system with this type of rotary bucket loader (matched with a chain bucket loader) + a continuous technology equipment earth moving bridge under the appropriate conditions is basically the same as the first system, and only requires that the rock and earth be slightly softer, without large boulders (for the chain bucket loader), and that the coal seam have a lesser grade (<5°). In the Zhaotong Coal Field in southwestern China, for example, we can give consideration to using this type of system for extraction. A large earth moving bridge (capacity 5,000-6,000 m<sup>3</sup>/h) matched with two medium sized rotary bucket loaders (upward digging) and two chain bucket loaders (downward digging) can be used for production. This method presents the problem of the developmental direction of chain bucket loaders. This equipment has the shortcomings of low efficiency and low cutting power. It is, however, a downward digging loader, and has obvious advantages for water drainage, production safety, and simple transport systems in the deep parts of a pit. An earth moving bridge is an essential piece of equipment, however, and should be studied and manufactured by the related departments.

## 2. Trucks and semi-continuous technology equipment

China produces quite a few different models of trucks used in mining. The main ones are 32 t, 60 t and 100 t models. The 100 t model is an electric turbine truck. Industrial experimentation is now being done in surface iron mines, and the results have been quite good. The Nanfen surface iron mine imported ten 120 short-ton electric turbine trucks from America. They have operated normally since being put into production.

The total amount extracted in large surface coal mines is much greater than in the metallurgical system in China. We should, therefore, develop even larger truck models, such as 150 t. Moreover, the truck beds should be installed so as to be easy to change. This will make it easier to transport smaller volumes of rubble, coal and other materials.

Besides single bucket electrical loaders, semi-continuous technology equipment also includes equipment systems of trucks + pulverizers + rubber belt conveyors. This eliminates the need for one of the pulverizers. There are fixed, semi-fixed and moveable types. The pulverizer of each model can be used in conjunction with a vibrating basket with a larger-hole grate. Hard rock can be dealt with merely by concentrating on the production link of blasting quality. According to foreign statistical information, only 5 to 10 percent of the material in the basket needs to be pulverized. Budgetary estimate indicators from China's metallurgical system show that the increased cost of crushing the large rock that has been excavated amounts to less than 0.2 yuan per ton. Therefore, there often are obvious advantages to semi-continuous extraction technologies when truck transport exceeds its economic transport distance. Semi-continuous extraction technologies not only are suited for hard rock, but also can be used for excavation of surface deposits of even greater hardness. This type of extraction technology has already been popularized and used in some surface iron mines in the Soviet Union. Some of the surface mines in China also are preparing to use this technique. Similarly, they should also be used in surface coal mines in China.

### 3. Single bucket rail technology equipment

Single bucket rail technology equipment refers to an extraction method in which a single bucket electrical loader is matched with rail transport. Surface coal mines in China now commonly use 4 m electrical loaders along with 80 t and 150 t electrical tractors matched with 60 t self-tipping equipment. The system has not changed basically in 30 years. The equipment has not been updated or replaced. There has been a tendency toward a reduction in the amount transported over the years as the depth of excavation and distance have increased. The amount transported in surface coal mines can be increased by 30 to 50 percent, if the current integrated electrical rail system substitutes 8 to 12 m<sup>3</sup> single bucket electrical loaders and a 200 to 360 t tractors fitted with a 100 to 180 t self-tipping cars and rebuilt electrical supply equipment for the existing outdated production system. Therefore, the advantages of this type of extraction technology (large amount transported, long transport distance and low costs) can still continue to be made use of.

The specifications of single bucket electrical loaders should be matched with transport equipment models. They cannot arbitrarily be made larger or smaller. There should be interchangeability in the models of electrical loaders so that they can be used in rail transport as well as truck transport. If China can put together a rail transport system with 100 to 180 t self-tipping cars within the near future (with the associated 100 to 180 t electric tubine truck system), then the 12 m<sup>3</sup> single bucket electrical loaders can also be used.

Therefore, the parameters for renovation of single bucket rail technology equipment (as well as for single bucket truck technology equipment) should be proposed by those working in surface mines in the coal system. We should strive to change as quickly as possible the overly small-scale specifications of single bucket rail extraction technology equipment in order to change existing production in surface coal mines and to establish the technological conditions for the creation of surface coal mines.

#### 4. Dumping technology equipment

This mainly refers to large-scale traction loaders and stripping machine loaders. Here, we only will introduce a large traction loader with a 15 m capacity bucket loader that should be in extensive use.

Foreign countries already have 8, 15, 25, 45, 70, 90, 100, and 145 m<sup>3</sup> traction loaders. China's surface coal mines have not yet used traction loaders in production. The deep parts of newly constructed large surface coal mines have the conditions to adopt this type of large-scale equipment. We should determine our own traction loader specifications (primarily bucket capacity and linear measurements) and systems based on the geological and burial conditions and the scale of extraction of the surface coal fields in China, and we should strive to put them into use in the newly constructed surface coal mines.

In 1964, when we were planning the development of several large surface coal fields in China, a program for adopting large-scale traction loaders was proposed, but because of accidents later, the tentative idea for the manufacture of this type of dumping technology equipment never became the order of the day, and there is no such equipment at the present.

### III. Production Capacity and Extraction Programs

Many factors of both technical and economic origins influence the production capacity and extraction programs of surface coal mines. Some factors still await measurement.

#### 1. Transport programs

Under conditions of guaranteed reserves, such as policy goals which are concerned primarily with the pursuit of coal output, we should first of all determine the amount to be extracted in a surface coal mine according to the transportation equipment of the mine or the annual transport capacity that can realistically be attained in the near future. In this way, the annual production capacity of a surface coal mine is equivalent to the quotient of the ratio of the annual extraction amount to the extraction ratio plus 1. The extraction ratio is related to the endowment conditions of the coal seam. The extraction ratio can be balanced when selecting extraction programs, and can even be taken as

a known amount. The question is how to determine the annual total extraction amount. We will now discuss several related questions based on the form of transport that is adopted (when using internal dumping):

#### 1) Truck transport

What is a rational total amount of extraction when a surface coal mine uses only truck transport? Current information at home and abroad cannot provide an answer. When the annual total amount extracted is exceptionally large, foreign countries usually adopt the pattern of integrated extraction (that is, many forms of transport) to scatter the large amount of material. China has already begun to deal with this question. How can the annual transport capacity of trucks be determined? What are the factors that influence it? Because there is no complete information at present for analysis of the measurement of annually rational total amount extracted in surface mines, we can only state the problem here. The Nanfen surface mine in southern China uses 25 t, 32 t, 100 t and 120 t trucks for dumping the material outside the mine at a transport distance of 1.7 km. The design total annual amount extracted is 37 million tons. The mine with the largest amount transported in America is the (Binhan) surface mine, with total annual extraction of about 100 million tons.

There are some economic factors that also influence the total amount extracted and extraction programs. One is the economical transport distance of trucks. The other is the amount of increased investment in trucks per unit of total amount extracted.

According to statistics from more than 50 metal producing surface mines in China, America and the Soviet Union, the average economical transport distance for trucks is 2.1 km. Therefore, the distance and depth of extraction in surface mines are subject to the limitations of economical transport distances. Because the trucks used in surface mining can utilize slightly larger beds, their economical transport distance should also be larger. The degree to which they are larger should be determined from the standpoint of economic analysis.

It can be learned from analysis of truck transport design information from China's metallurgical system that the investment in trucks per unit of total amount extracted increases as the total amount extracted increases. That is, there is a corresponding increase in the amount of investments for an each additional 1 t (or 1 m<sup>3</sup>). With 100 t electric turbine trucks, the increased investment in trucks per unit of total amount extracted is 0.97 yuan/ton (with a total annual extraction base of 30 million tons and an average transport distance of 2.5 km): it is 1.30 yuan/ ton when the average transport distance is 3.7 km. There is a tendency toward a straight-line increase in these values. Therefore, it can be predicted that this index will be one of the conditions that will restrict an increase in the total amount extracted using truck transport.

## 2) Semi-continuous technology equipment

This is a technical means for extending the transport distance of trucks. This is especially true when there is an obvious economic irrationality. Based on analysis of data from China's surface iron mines, pulverizer costs in semi-continuous technology amount to about 0.2 yuan/ton. It is estimated that the value for surface coal mines will be lower than this.

At what depth is it best to make a changeover from all truck transport to semi-continuous technology patterns (when semi-fixed pulverizer stations are used)? There is no one answer. For example, 100 t turbine trucks are used to a depth of 200 m in the Soviet Union, to 60 m in the United States, to 90 m in Japan, and to 80 m in China (in surface iron mines). The value to be used in China's surface mines must be determined through further study and determination to guide design.

The results of semi-fixed pulverizer stations are fairly good, but no single-engine pulverizing equipment with a production capacity greater than 1,000 t per hour is manufactured in China. This requires us to organize its development or importation.

## 3) Rail transport

Just as in truck transport, a moveable main line must be adopted if there is internal dumping and extraction is carried out on a single flank. It is most appropriate to install three main lines (two heavy and one empty). This can transport an annual total amount of extraction of between 20 and 25 million  $m^3$  (equivalent to extraction of 5 to 6 million tons of coal annually in a surface coal mine with an extraction ratio of 4  $m^3/t$ ).

Because the bench of the main rail transport line is long (the work area occupies a large proportion of a triangular bench), it increases the amount of construction engineering and also limits the degree of advance, which makes it difficult to increase output. If the total number of benches is limited, there can be internal dumping at the railway turnaround center. The latter forces the work line to assume a fan shape for advance. This is a new subject that is encountered when adopting rail transport, and it requires thorough study.

## 3. The question of internal dumping.

The five large surface coal mines that China is about to develop are all located in the north. There is not much precipitation, and the coal seams have an inclination of 7 to 8 degrees. These are excellent conditions for establishing an internal dumping ground after they go into production. Internal dumping touches on many problems, such as the height of the piles, the pressure-bearing capacity of the coal seam's base, the concentrated stress on the base line of the slope, slope stability during the rainy season, and so on.

All of these require preparatory study and measurement to meet engineering requirements. An example is the (Fuqisa) surface coal mine in Czechoslovakia. The inclination of the coal seam is  $6^{\circ}$ . On the coal seam base, after the method of water drainage and increased friction coefficients was adopted (with large boulders dumped at the base) the height of the dump has reached 150 m and the total amount dumped was 150 million  $m^3$ . There have been no major abnormal phenomena.

Using downward excavating equipment on the bench at the lowest part of the surface mines (such as bucketwheel loaders, chain bucket loaders or traction loaders), is favorable for solving safety conditions in surface mines (falling rock, etc.) The Soviet Union has been able to achieve an internal dumping angle of  $15^{\circ}$ , and we can borrow this experience.

### 3. Collapsing extraction techniques

As mentioned above, the use of collapsing extraction techniques at the rock benches at the lowest part of a surface pit can simplify the distribution of extraction lines at the bottom of the pit, guarantee the safety of internal dumping, and reduce the costs of extraction. For example, the costs of this type of extraction are only one-fourth the costs of rail transport (in the Soviet Union) and one-third the costs of truck transport (in the United States).

Production tests in America and the Soviet Union have proven that large scale traction loaders (with a bucket capacity over 15 m) are suited to rock of medium hardness (a Pope coefficient of  $f \leq 8$ , after blasting). They are extremely useful and the results are good.

### 4. Integrated extraction technologies

All of the world's large surface mines have adopted integrated extraction technologies. An example is America's (Shuangfeng) [Two Peaks] surface mine, which has an integrated program based on rail and truck transport. West Germany's (Feiertuna) surface lignite mine has adopted continuous extraction technologies and an integrated program of traction loading and dumping extraction technologies in deep areas. The Yongshi surface coal mine in the USSR adopted continuous extraction technologies, with an integrated program of single bucket loaders with rail transport and rotary bucket loaders with rail transport (for shipping coal).

The five large surface coal mines that are to be constructed in China are more able to quickly go into production and expand production. Initially, we can adopt the extraction technology of single bucket loaders matched with truck transport in all of them. After they go into normal production, we should give consideration to adopting integrated extraction technologies. An example is the Jungar surface coal field in Nei Monggol and the Pingshuo surface coal field in Shanxi. Consideration can be given to the adoption of continuous extraction

technologies for the topsoil portion (comprising one-third of the amount removed). In the middle part (rock of medium hardness), the extraction technology of single bucket loaders matched with truck transport can be adopted. In the deep part (rock of medium hardness), an integrated program of extraction technologies using traction loader dumping can be adopted. In the several surface lignite mines in Nei Monggol, consideration can be given to using continuous extraction technologies in the upper part (soft rock), and to the adoption of single bucket loaders matched with truck transport or semi-continuous technologies in the middle and deep parts (rock of medium softness). Because the rock of the capping layer is relatively soft at the Zhaotong surface coal field (lignite) in Yunnan, consideration can be given to an integrated program of extraction technologies using single bucket loaders or rotary bucket loaders matched with rubber belt conveyors in the upper part, and to continuous extraction technologies using large earth moving bridges in the middle and deep parts.

Integrated extraction technologies often involve adoption of multiple types of equipment. This is indisputable from the point of view of management and maintenance. The main reasons for recommending this type of extraction technique are: Integrated extraction technologies are quite suited to the most favorable materials circulation for a large increase in the total amount extracted in construction of large-scale surface coal mines. Mine extraction equipment can be selected according to geological conditions so that each is properly used and can give fullest play to the usefulness of the equipment and improve the economic results of extraction. This is better than a single form of extraction technology.

## 5. Coal quality and processing

The users of the five large surface coal mines are pit-mouth power plants and domestic and external buyers. The coal quality is power coal and lignite.

Power coal is shipped out and sold domestically or abroad. This type of coal must be dressed, which can reduce the amount of gangue that is shipped out and raise the selling price of the coal. The coal chunks and the end coal beneath the basket can be supplied to users at pit-mouth power plants. Fairly good economic results can be gained through this arrangement.

The problem concerns lignite with a low thermal value. The average thermal value required by power plant boilers usually cannot be less than 2,700 Kcal/kg. An increase in the ash content will be the result if too much gangue is mixed in when extracting the raw coal. This can lead to greater problems in boiler manufacture. This directly affects investments in the boiler pre-feeding equipment manufacture system and the slag and smoke exhaust systems. We propose here that the selection of comprehensive lowest cost programs for extraction, coal dressing and power generation, requires multifaceted technological and economic

proof. An example is the North Czechoslovakia mining region. The expansion of a surface lignite mines required the recovery of coal left over from a shaft mine. Two types of programs were proven because of the ash content question: selective extraction (reduce the capacity of rotary bucket loaders and improve coal quality) + coal dressing (because the ash content is reduced, the cost of dressing the coal is lower) and mixed extraction (the capacity of rotary bucket loaders is not decreased, and the ash content is slightly higher) + coal dressing (because the ash content is slightly higher, the cost of dressing the coal increases). The first type was adopted after economic comparison. Some of the lignite surface mines in China contain several gangue layers with high ash content and an uneven planar and depth distribution. Now, we should pay attention early to the question of the evenness of coal quality during extraction, and we should extract according to plans or rules and to the programs for coal dressing and power generation that have the best economic results.

#### IV. Evaluation of the Economic Results of Investments

Currently, although the price of coal differs from its cost, this definitely does not imply that we can give up or ignore its importance. We have not yet put into practice the idea of taking the smallest amount of investments and administrative expenses (depreciated to an identical standard annual limit) to serve as an indicator for evaluation of economic results. There still must be long-term effort and testing on the coal battlefield. Two questions must be solved in this area:

- 1) We must propose a constructive approximate departmental investment standard earnings rate (static and dynamic) based on data from model enterprises in China during periods of normal economic activity and on actual conditions in related foreign enterprises to serve as a common base for economic comparison of various programs. It is not easy to plan an investment standard earnings rate that is suited to the situation in the coal system in China. Now, however, the formation of an approximate standard (departmental standard) to serve as a common basis for economic comparison of programs is still beneficial for progress in capital construction work.
- 2) The question of calculation methods in economic comparisons can involve either static or dynamic calculations. All western countries have adopted dynamic methods for calculation. The Soviet Union has further adopted dynamic methods for carrying out calculations during the period of its 11th Five-Year Plan (1981-1985). Based on China's capital construction investments moving further toward a loan system, on the importation of a relatively large number of surface mine equipment, and on other conditions, we also should adopt dynamic methods for calculations. In this way, we can implement comparative investment standards earnings rates standards and calculation methods. This is of overall benefit for selection of the best programs (or next-best programs).

New construction and expansion of large scale surface coal mines should attain output goals and increased economic benefits as quickly as possible. Mining equipment should be based on domestic manufacturing levels. This is a material basis for maintaining continuous and stable production in our country's surface coal mines. We also should actively organize the importation of any advanced foreign equipment that is suited to extraction conditions in China. The imported equipment should be established so that it has a "long life and strong operations". Quick-wearing parts should be based on domestic supplies. Otherwise, there can be enormous variations in production levels.

The geological and natural conditions of China's surface coal mines are relatively complex. This is true in addition to the large degree of extraction and the need for rapid coal production. Many problems will be encountered. We cannot indiscriminately copy ready-made foreign technologies and experience. By maintaining continuity in the technological development of our surface coal mines we will see results within the next 10 years.

12549

CSO: 4013/191

## COAL

### ACCELERATING DEVELOPMENT OF FULLY MECHANIZED COAL MINING

Beijing MEITAN KEXUE JISHU /COAL SCIENCE AND TECHNOLOGY/ in Chinese No 1,  
25 Jan 84 pp 2-5

/Article by Vice Minister Ye Qing, Ministry of Coal Industry/

/Excerpts/ Under the guidelines of the 3d Plenum of the 11th Party Congress, there have been significant changes in the coal industry. In terms of the leading ideology, we have brought order out of chaos. On the basis of the positive and negative experience of the Chinese coal industry in the 30 years since the founding of the country, a new approach to the development of the industry in a new era was drawn up by referring to the technological development in major coal producing nations. The seriously imbalanced situation was changed through adjustment and reorganization. It began to march toward a stable, healthy development. The reform of the economic system was initiated and some preliminary experience was acquired. The idea of relying on scientific and technological progress was implemented and some achievements were obtained.

Despite many ups and downs the mechanization of coal mining has also made significant progress, especially since fully mechanized coal mining started relatively late. Its development began in the early seventies. It was not possible to absorb existing achievements from major coal-producing countries in view of the situation back then. In addition, not enough effort was put into this work, so the progress was very slow. After the "gang of four" was crushed, the party and the government paid a lot of attention to the renovation of technical equipment for coal mining and improvement of working conditions for the miners. It was decided to import 100 pieces of fully mechanized equipment from the West. In the meantime, a considerable amount of fully mechanized equipment was to have been imported from Eastern Europe and Russia to facilitate mechanized coal mining in China. However, due to a lack of experience, manufacturing technology was not introduced as the equipment was imported to expand our production capability. The understanding of mechanized coal mining was not unanimous and development was delayed. After the 3d Plenum of the 11th Party Congress, the understanding of mechanized coal mining was unified on the basis of experience and the direction for the development of fully mechanized coal mining was redefined. Advanced foreign technologies will be introduced according to plans. Foreign businesses will be selected for cooperative manufacturing. Moreover, research, design and manufacturing will be concentrated to actively develop Chinese-made fully mechanized equipment while digesting imported technology. Consequently, fully mechanized coal mining can be developed along a steady, healthy path.

It is estimated that mechanization in coal mining in 1983 reached 41.8 percent, of which full mechanization represented 21 percent. The average production of a fully mechanized work face can reach 35,000 tons, with an efficiency of 13.3 tons/worker. A number of highly-productive and efficient fully mechanized teams have emerged in China. The annual production of eight such teams exceeded 1 million tons. The best annual production could reach 1.2 million tons. In addition, a scientific research, design and manufacturing team serving fully mechanized excavation has already been formed. To date, it has already successfully developed stack type, joint type, shielded type and protected shielded type of hydraulic supports; various single- and double-roller coal extractors; high-power conveyers; bridge-type transporters, flexible belt conveyers; kilovolt-level electrical equipment; communications, control and illumination devices. These devices are now in batch production. As of the end of 1983, 83 sets of Chinese-made fully mechanized excavating equipment had been manufactured. We will continue to expand and perfect in order to be self-sufficient in fully mechanized equipment. The practical experience in using fully mechanized equipment over the decade shows that it is the direction of development. Its superiorities are being demonstrated:

1. It is an imperative way to raise unit area yield and to stabilize and increase production. Fully mechanized coal mining has a relatively high unit yield and efficiency. The unit yield of a fully mechanized extracting face is equivalent to that of three conventional extracting faces or four explosion faces. The efficiency is 3.3 times that of conventional extraction or 4.5 times that of blasting extraction. Particularly, fully mechanized extracting equipment has a higher resistance against changes in natural conditions. Under the same situation, a fully mechanized extracting face can provide more stable production. The potential to improve unit yield of a fully mechanized face is higher. For example, in the 5 years from 1978-1982, the average annual growth in unit yield in a fully mechanized face was 2,200 tons. As long as the pattern is grasped, productivity can be further improved.

2. It is an important measure to improve conditions in order to realize production safety. It is necessary to combat natural disasters such as gas, coal dust, and cave-ins while working in the pits. The work and safety conditions are poor and in all incidents involving death and injury, roof accidents always account for 42-45 percent of the total. Fully mechanized coal mining not only reduces the labor intensity of the workers but also permits them to work in a safe environment to ensure safety. According to statistics, the casualty rate per million tons in a fully mechanized face is only about 15 percent of those in other work faces. The rate of minor injury is also greatly reduced. It has a convincing effect on maintaining the morale of miners, lengthening the working time in the pit, changing the unsafe image of coal mines and solidifying the coal mining team.

3. It is an important foundation for the rational centralization of mine production and the promotion of large-scale mining. The rational centralization of mine production is an important technical policy in coal mining. As the mining depth and area continue to increase, the production links become more complex, leading to higher costs and lower economic benefits. In order to change this trend, we must continuously reform mining technology. However, one

of the important contents in technological reform is to concentrate the extracting area and work face to the extent possible as we improve the major links in the mines. Only by doing so, we will be able to simplify the links to obtain the optimal economic benefit. To rationally centralize production is determined, to a certain extent, by the production technique and unit yield. Fully mechanized coal mining greatly raised the yield in a single unit. Furthermore technical reform and centralized production will provide good conditions for fully mechanized equipment to be most useful. The combination of the two will also serve as the basis for improved economic benefit in mines suited for large-scale production.

4. It is a reliable way to overcome some technical problems in coal mining. For many years, there have been some difficult technical problems in mining coal from medium and thick coal beds on a slow incline. One of them is the 2.5-3.5m thick coal bed. Because of the limitations of support materials and operating conditions, it is not appropriate to divide it into layers. Usually, only 2.3-2.5m is extracted and the remaining coal is abandoned. The second is a short-range or broken roof coal bed. Because the roof is hard to manage, it results in low unit yield, a high number of injuries, and a poor extraction rate. The third is a hard roof. Because of the lack of support strength, coal is usually mined by a column method. Not only is a lot of coal discarded, but also it is susceptible to spontaneous combustion. The fourth is that mechanized coal mining is not easy in areas of complex geological structure which may lead to excessive excavation. The special feature of fully mechanized coal mining techniques is that a 3.5m or higher layer can be extracted. There is no more coal abandoned. Next, because hydraulic supports can seal the overhead beams of the entire work face, proper measures can be taken to manage a broken roof. When the roof is hard, because the support strength and shearing power of hydraulic supports are high, the roof management problem is solved. Mining along an incline in a geological structure may be possible. These features are the new developments in coal mining.

Over the past decades, although there has been significant progress in mechanization of coal mining in China, there are gaps in quantity as well as quality when compared to major coal-producing countries in the world.

1. The development is imbalanced and the full benefit of the mine is not realized. Over the years, although there have been some highly productive and effective teams, a considerable number of teams still could not produce more than 200,000 tons annually. The efficiency is only 7-8 tons/worker. The utilization rate of fully mechanized equipment in some bureaus has approached 70 percent. However, in other bureaus it is only 30 percent or so. The mechanization of coal mining in some bureaus has exceeded 90 percent, and the fully mechanized mining ratio is 1/3-1/2. However, the mechanization in some bureaus is only around 10-20 percent with a fully mechanized mining ratio of about 5 percent. The direct benefits of most fully mechanized mining faces are usually good. However, the overall benefit of the entire mine is not apparent. From these imbalanced developments one can pinpoint the problems as well as the potential.

2. Scientific research and manufacturing can still not meet the needs of full mechanization. Fully mechanized mining equipment cannot be produced in series, and a breakthrough in fully mechanized mining equipment for thin, thick, and steeply inclined coal beds has not been made. In addition, the number of fully mechanized mining equipment is small, the quality is unstable, the cost is high, the supply of main equipment and accessories is not coordinated, and technical services are not widespread, which directly and indirectly hinder the development of fully mechanized coal mining.

3. Poor team quality affects the effectiveness of the fully mechanized equipment. The poor business knowledge and management level are reflected in some of the leaders. Small-scale production methods are still used to organize modern fully mechanized production. Next, the cultural standard of the fully mechanized mining teams is generally low, which affects the effectiveness of advanced equipment.

4. Progress in fully mechanized coal mining has been slow because of the lack of a stable economic policy. Progress was faster in 1979, 1980, and 1981. On average, mechanization increased by 4.65 percent a year, which was due to a one-time investment to acquire over 100 pieces of equipment. However, there is no fixed conduit for future capital and depreciation and repair costs of existing equipment are not charged. As a matter of fact, the equipment is utilized without any compensation. The business does not have the ability to renovate. Equipment maintenance cannot catch up with it. There is the potential worry that the equipment will become totally worthless.

The 12th Party Congress mentioned the quadrupling of the total national economy by the end of this century. For this reason, the coal industry, which accounts for more than 70 percent of our energy resources, must quadruple its production. Hence, the Ministry of Coal Industry indicated that coal production must reach 1.2 billion tons by the end of this century. This requires a faster rate of development in the coal industry. The new progress must be based on advanced science and technology. Specifically, the five changes (i.e., changing from manual to mechanized production in key coal mines; from inability to control major incidents and occupational diseases to fundamental control of such things; from producing coal alone to various products; from operating individually to operating collectively; and from the backward storage and transport system to a multiple mode transportation system) must be realized.

Technology has a determining effect on production techniques. The completion of a technological conversion is the core of the realization of the five changes from start to finish. Coal mining technology includes coal mining methods, excavating methods, and expanding arrangement. However, the most important thing is coal mining techniques. New coal mining techniques and equipment must be chosen according to the locality to facilitate mechanized coal mining. From the actual situation in China, we must thoroughly implement the policy to develop full mechanization, improve conventional mining, and use water extraction when possible. We must actively create conditions to use fully mechanized equipment. Especially in suitable new pits, we must attempt to expand the useful range of fully mechanized mining. Conventional mechanization must be rapidly reformed to completely renovate existing supports and conveyers in 3 years or so to

improve the safety, reliability and contingency ability. In mines where hydraulic extraction is appropriate, especially in areas where mechanization is not suited, we must actively pursue hydraulic extraction and perfect it. In the "Sixth 5-Year Plan" period, the extent of mechanization in extracting, digging, and shipping is required to reach 50 percent. It is required to reach 70 percent in the "Seventh 5-Year Plan" period and over 80 percent by the end of this century to fundamentally mechanize coal mining.

In the process of realizing this conversion, we must implement the principle of self-sufficiency and absorb advanced technology for cooperative production. On the basis of using existing equipment to continually improve effectiveness, mechanization of coal mining will be developed actively and steadily. We must pay attention to the following:

1. We must combine mechanization of coal mining with selecting advanced coal mining equipment, reforming mining technology and modifying lane arrangement. We must recognize that advanced equipment can be highly productive, efficient, and safe to solve many difficult problems in coal mining. However, we must also understand that advanced equipment will require a higher standard for the exploration plan and lane arrangement (i.e., it will require larger mining links, sufficient buffer room, larger lane cross-section and higher engineering quality). The technical advantages of the new equipment will also be fully utilized to reform mining technology and arrangements in order to expand the applicable range of the new equipment and to make it more effective. The two should complement each other continuously to raise the economic benefit.
2. We must concentrate our strength to overcome the weak links in mechanization within a short period (i.e., 2 to 3 years) to form a coal mining mechanization series suited for coal exploitation in China. The weak links are the mechanization of thin coal beds and steeply inclined coal beds. If the mechanization of thin coal beds cannot be solved, then the production of the underlying thick coal beds is limited. Or, because of production goals, thin coal beds are abandoned, leading to a great loss in energy resources, or the exploitation of bottom thin coal beds is delayed, which causes difficulties in later stages and fluctuation of production levels. As for the mechanized mining of steeply inclined coal beds, it is not only related to improving the production level but also to the resolving of natural factors affecting safety in the pits. Therefore, any breakthrough in these two weak links has an extremely important effect on mechanized coal mining.
3. We must determine the rational coal mining equipment and technique based on the overall benefit by taking various factors into consideration. A coal mine is an underground operation. Spontaneous combustion of coal and gas, water, roof and floor and coal bed structure all have different effects on production. However, these natural conditions are also constraining one another. From the viewpoint of fully mechanized coal mining, the longer a work face moves along the fewer the number of relocations. However, if the coal combusts spontaneously, fire prevention becomes difficult along a long path. Therefore, if a policy is made based on one aspect, then we will only attend to one thing and lose control over other things. Our projected goal cannot be reached. As another example, when we select the requirement, the key links of the entire

mine must be used in the analysis to avoid any mismatches. In summary, the optimal benefit can be obtained by grasping the major contradictions in production, practicing comprehensive management and selecting rational coal mining techniques and equipment for the whole mine.

4. We must combine solid scientific management with mass motivation. The initiative of the people must be motivated in organizing coal mine production to improve the benefit of advanced equipment. To start off with socialist labor contests and mass activities to study and catch up with the advanced standard in order to break the million-ton mark is an important way to motivate the enthusiasm of the people. It is necessary to guide the enthusiasm of the people motivated by socialist labor contests to the track of scientific management. Both quality and quantity must be considered simultaneously. We must closely combine mass motivation with quality control. A scientific method must be implemented at every post as the people struggle to meet their objectives.

5. The reorganization of the coal mining machinery manufacturing business and its technical reform must be grasped in order to finish the shift to independence as soon as possible. It is impossible to simply rely on buying foreign equipment to develop mechanized coal mining rapidly in a large nation such as China. We must take the opportunity, as we import the technology, to reorganize and reform our factories to become independent in order to satisfy the growing demand and to promote further mechanized coal mining.

The mark of independence is to meet international standards in production quality. For example, in 1986-1987, a coal extractor will be required to operate in the pit for 600 hours and travel 150,000 meters without opening its covers. By 1990, it will operate for 1,000 hours and travel 300,000 meters without lifting any cover. The domestic demand must also be met in quantity; 600 coal extractors will have to be built annually. In addition, a complete series will have to be established specifically based on the characteristics of coal fields in China. The equipment will be standardized and generalized. The cost of equipment will also be gradually lowered. As the first step, it should be reduced by 10-15 percent on the basis of present prices.

In order to realize this goal, we must first reorganize the existing factories. Based on the long-range plan of the coal industry, we will concentrate the production of main equipment and develop a professional cooperative relation. On the basis of existing industry, both quality and quantity will be improved. Next, we will proceed with technological reform in existing plants. Under the principle of not increasing personnel and plants, the quantity and quality of new equipment will be improved through technological reform. We must also insist on consolidating scientific research, design, manufacturing, and production. Scientific research will deal with elements and components in order to control standards. Manufacturing will emphasize the study of technology to deal with product quality. Production will provide experimental sites to actively coordinate the testing and improvement of new products. They have different emphases, however, they are also mutually complementary.

6. We must pay attention to the training of existing personnel to improve their political and professional quality. People are the key to successful

mechanization in coal mining, especially to the accelerated development of fully mechanized coal extraction. From a long-range viewpoint, we should educate people in order to supply various talent to the coal mines. From a near-term viewpoint, it is more important to train existing personnel to improve their standards in order to satisfy the needs of mechanization.

We must correct the concept of training in order to train existing personnel well. Training should be considered as a strategic measure related to the "Four Modernizations." It is an exploitation of wisdom, which must be treated solidly. Next, cadres may be selected to leave the production line to go to school to undertake systematic studies. Or audiovisual and correspondence education should be developed to allow the cadres and workers to study systematically on the job.

12553

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## COAL

### GAO YANGWEN TAKES AIM AT PROBLEMS IN COAL INDUSTRY

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[Text] The leading party group of the Ministry of Coal Industry convened a conference of party members from ministerial organizations. Comrade Gao Yangwen made a comparative examination as representative of the leading party group in the ministry.

After party consolidation in the Ministry of Coal Industry had entered the comparative examination stage, the ministry's leading party group acted in accordance with the CPC Central Committee decision on party consolidation and Circular No. 7 of the Central Committee Party Consolidation Work Guidance Committee. Beginning on 16 March ministers and vice-ministers carried out comparative examinations at a meeting of the leading party group followed by an enlarged meeting of that group. On the basis of individual comparative examinations, they convened a conference of all party members in the ministerial organs and units located in Beijing on 6 April to carry out collective comparative examinations of leading party groups. The meeting was attended by comrades from the CPC Central Committee Party Consolidation Work Guidance Committee, the Leadership Group for party consolidation in industry and communications, the Central Discipline Committee and party committees in state organs. Representatives from all democratic parties in the Ministry of Coal Industry and upper-level intellectuals were also invited to participate in the enlarged meeting. The meeting was chaired by Comrade Yu Hongen [0061 3163 1869], deputy secretary of the ministry's leading party group and vice-minister.

While discussing the key points of the comparative examinations as representative of the comparative examination in the leading party group. Comrade Gao Yangwen said, "The examinations of leading party groups focus on the main problems in implementation of the party's lines, principles, and policies. In real terms, it concerns the strategic goal of 'doubling to assure quadrupling' and the creation of a new situation and opening up new roads in the coal industry." He said that this means that we are shouldering an historical responsibility in consideration of the special importance of the coal industry for achievement of the overall goals and tasks of the entire party. Doubling output in the coal industry during the current five-year plan is the least that can be done to assure that the entire nation can quadruple the value of production by the year 2000. It is a

goal where no retreat or wavering can be permitted. The degree to which we can complete this enormous task is an important indicator of whether or not we have been consistent with the CPC Central Committee. The leading party group feels, therefore, that the comparative examinations cannot be separated from this central point.

In looking back on the practice of the past few years, the leading party group has earnestly analyzed the opinions of ministry organs and basic-level comrades. In the overall picture, the leading party group feels that it has been striving to adhere to the Four Basic Principles and that it has been striving to maintain ideological and political unity with the CPC Central Committee. One aspect is that there has been an earnest, active and resolute attitude toward implementation of the lines, principles and policies following the 3d Plenum of the 11th CPC Congress. The second is that attention has been paid to integration with reality, and that concrete principles, policies and measures have been formulated that are suited to development of the coal industry. The third is that preliminary practice has shown that the results are good and that there have been improvements in our work. We are beginning to take steps to create a new situation in the coal industry. There has been progress and good prospects are appearing. However, the distance from the demands the CPC Central Committee has placed on us is still quite great. Our ideology often does not keep pace with circumstances and our work does not meet the needs of developing the coal industry. This shows in a concentrated way that we have an inadequate understanding of the special importance of achieving the strategic goal of "doubling" to assure quadrupling" and that we lack firm confidence and determination when we encounter problems. It also shows that we have not been open nor had a pioneering spirit in relation to opening up new roads and creating a new situation in the coal industry. We also have not implemented the measures for opening up that were proposed. For this reason, the new situation in the coal industry has not taken shape.

As representative of the ministry's leading party group, Comrade Gao Yangwen first of all investigated the problem of the lack of stable and firm confidence in achieving the strategic goals of the coal industry. He said that the leading party group had confidence in as well as misgivings about achievement of the strategic goals of "doubling to assure quadrupling" and opening up a new situation and new roads. It was in a state of shaky confidence. This lack of stable and firm confidence was not related to the goal of 1.2 billion tons itself, but to the 800 million tons for unified distribution, as well as to the new construction of 400 million tons. They were especially anxious about the key role of the 200 million tons from open-pit mines. They were even more anxious when major problems related to the overall situation appeared. One aspect was difficulties in materials, primarily funding problems. The second was differences in understanding and the fact that they had thought of quite a few methods. In relation to a strict examination based on the spirit of the 12th CPC Congress, however, they did not have enough of a pioneering spirit and lacked courage in opening up new roads, creating a new situation and not giving up when goals were not met. They lacked the fearless spirit of marching forward courageously and being duty-bound not to turn back. There was no indomitable

spirit of trying again and again until a goal was achieved. At times, they even surrendered to difficulties, surrendered to reproach, wavered and retreated. This spiritual attitude of the leading party group directly affected leading cadres at all levels. This problem could be found to different degrees within ministerial organs and throughout the entire battle-front. From now on, we must make a firm decision and fully realize that there can be no retreat from the goal of 1.2 billion tons. We must not be content until we have achieved this goal. We must be firm despite the difficulties we encounter. If we do not achieve it and simply give up, then we will never be satisfied to the day we die.

Next, Comrade Gao Yangwen, as representative of the ministry's leading party group, investigated questions due to the failure to eliminate the remnants of "left" ideas, the lack of courage in opening up to the outside and working actively within the country and the small steps toward reform that influenced the development of a new situation in the coal industry and were not suited to the demands of "doubling to assure quadrupling." He said that although a lot of work had been done to open up to the outside and some progress had been made in such areas as the substantial progress in joint investments to open up the Pingshuo open-pit mine, in terms of the overall situation, ideology, policies, and restrictions had not been opened up. The utilization of foreign capital was limited and the forms were not dynamic. A great deal of capital that could be used had not been released for use. There have been slow developments in joint investment and administration, cooperative planning and cooperative manufacture.

The coal industry has been slow and the steps to make reforms have been small. Enterprises lack dynamism, and there has been a long period of poverty and backwardness. The enthusiasm of employees has also been restricted. The attempts at reform in recent years have been only minor hit-and-miss affairs. Making the enterprises dynamic requires solving some fundamental problems and there have been no major breakthroughs. There have been no studies on comprehensive programs for reform of the economic management system suited to the special characteristics of the coal industry nor for special methods for coal mine reform. The ministry has not turned over sufficient administrative powers to the enterprises. That which should be managed has not been managed well and that which should not have been managed has been managed too much, to the point of excess. The ministry's leading party group has had an erroneous tendency in its guiding ideology that stresses production while neglecting administration. Management and administration has not received sufficient attention and the enterprises have not moved from focusing merely on production to dealing with production and administration.

Leadership and direction of capital construction is also scattered and weak. Progress in reform of capital construction has been slow and there have been no major breakthroughs in reform of techniques and designs, in the construction and putting into production of large mines according to different periods, in the advance supply of coal and other areas. Construction work throughout the coal mines has taken a long time. There has been no fundamental reversal of the situation of low efficiency, high prices and enormous waste.

There has been insufficient leeway, encouragement and assistance for the development of small local coal mines. Small collectively owned coal mines in communes and brigades should be given more freedom and made more dynamic. There has been legislation and more responsibility, but the legislation and responsibility are for the purpose of even greater freedom and dynamism. We have not done enough work to implement these aspects. This is especially true in the failure of our knowledge to keep pace, and the work for unifying our ideology has not been done well.

There are, of course, several objective reasons for our failure to open up to the outside, enliven things within the country and take large steps for reform. In terms of subjective reasons, however, a major one has been inadequate liberation of our ideas. "Left" influences such as sealing off the country, parochial arrogance, and conservative complacency have not been eliminated. The situation of sticking to convention and following the old ways, the forceful influences of petty production customs, and rigid or semi-rigid ideology have not been completely destroyed. In another area, work has not been carried out well. Organization has been poor and there is no working style of working to the finish. This is another reason.

During his comparative examination as representative of the ministry's leading party group, Comrade Gao Yangwen also investigated the inadequate establishment of reliance on scientific and technical progress and stress on intellectual development due to the influence of the force of old customs. This has obstructed the progress of modernization and affected the creation of a new situation and achievement of "doubling to assure quadrupling." He said that the ministry's leading party group has recognized the importance of relying on progress in science and technology for vigorous development of the economy and achievement of quadrupling output as stressed repeatedly by the CPC Central Committee and State Council. This spirit also has been embodied in the formulation of new routes for developing the coal industry, but the progress of work has been slow and the results are far from ideal. This is most apparent in the lack of breakthroughs in 10 areas. These areas are: design reforms, technical policies, intellectual development, technical transformation of mines, manufacture and utilization of safety techniques and equipment, service to production and construction by scientific research, cooperation in the manufacture of specialized equipment, fundamental work in technical progress, cooperative organization of the forces which directly determine technical progress, the technical equipment and measures in geology, design, construction, scientific research and safety. He analyzed the two main reasons for this situation. The first is an inappropriate guiding ideology. The long-term administration of the coal industry through manual labor and small-scale production has led to neglect of science, technology, and education. There has been discrimination against intellectuals and a conservative ideology that is safely installed in this backward situation. Many comrades have a stronger spirit of backwardness than spirit of renewal and progress. In their work, they feel that old ways are safe and are always afraid to adopt new techniques, technologies and equipment. They are accustomed to doing familiar things and taking well-worn paths. This following of the old ways in our guiding ideology is one of the major reasons for the limited progress in science, technology and education.

Another reason is that there has been no impetus from within and no pressure from without in work to develop science, technology and education, and that they do not have the required strength in their hands. This problem is found not only in the enterprises but in the ministry as well. The ministry has not solved many more problems for the enterprises in this area. This directly influences the enterprises and means that many questions that have been clearly stated have not been implemented.

In his investigations, Comrade Gao Yangwen also examined the inability to adapt to the requirements of creating a new situation and achieving strategic goals caused by the lack of effectiveness in building a socialist spiritual civilization and by laxity in ideological and political work. This is a right deviation in the leadership of the ministry's leading party group. He said that, in looking back on the past few years, although we have done some work in strengthening the construction of socialist spiritual civilization, construction of socialist spiritual civilization has received far less attention than economic construction in the coal system. Some work has been done and there have been serious discussions, but looking at the overall picture, they still are at the stage of generalized needs. A fairly high proportion of those arrested and punished during the recent national attack on criminal offenders were coal mine employees. This clearly indicates that ideological and political work in the mines has been feeble. We gained the following understanding after summarizing experiences and lessons in this area: First, the economic departments which administer the coal industry for the State Council have an inadequate understanding of concentration on the two types of civilization. Party work and ideological and political work in coal enterprises depends primarily on the leadership of local party committees. The Ministry of Coal Industry also bears some responsibility, however. This is especially true in dealing with the special characteristics of coal mines. The ministry has the primary responsibility for opinions on strengthening ideological and political work and on adopting strong and effective measures. Although we have acknowledged this, we have not done it strongly or often enough in our actual work. Second, our understanding of the position and role of ideological and political work during this new era has not reached the high degree of understanding called for by the Report of the 12th CPC Congress. Creating a new situation in the coal industry and opening up new roads is manifested in both the material and spiritual realms. We want to reach the goal of 1.2 billion tons and substantially increase the ideological consciousness of the employees. Our lesson is to bury our heads in economic work and to neglect the building of spiritual civilization and ideological and political work. We have not adhered to the position of ideological and political work as the "lifeline". We have not adhered to the objective law that guaranteeing the socialist direction and socialist nature of coal enterprises is possible only if we pay attention to building spiritual civilization. Our limited knowledge of this question naturally means that our work has not progressed. Third, we have insufficient knowledge of the new characteristics of coal mines employees during this new era. For this reason, we have not paid enough attention to taking these new characteristics as the starting point and building a new large army in the coal industry. Our employees have the special characteristics of being hard workers at difficult jobs, but there are serious weak points. The quality

of both cadres and workers is fairly weak. Added to the terrible working conditions and poor safety conditions in the mines at present, this has meant that the underground ranks are far from consolidated. This is a serious obstruction to achievement of the strategic goal. We understand this, but our understanding is not complete or thorough and we have not made a major effort to deal with it.

Comrade Gao Yangwen also examined the weakness in organizational construction in the ministry. This has caused impurities in the ideology, organization and working style of cadres in the organizations. It has seriously affected the creation of a new situation in the coal industry and the achievement of "doubling to assure quadrupling". He investigated three main areas: One is serious bureaucratism, which manifests itself in irresponsibility and negligence. There is not enough investigation, research, examination, supervision or convincing models. We have not clearly established an ideology of whole-hearted service to the basic levels or an ideology of service to production and construction. Another is a serious evil wind. In the past several years, we have disregarded the repeated injunctions of the state. We gave certain things to the employees which created bad social influences. At the same time, the evil wind has not been killed because we did not do enough to educate the cadres or make strict demands on them. Some people treated coal as their private property. Others used administrative funds and materials and the power to redistribute personnel or the working conditions of project approval, the granting of funds and the supply of materials to transfer residence permits, arrange for jobs, buy cut-rate goods, give banquets and buy gifts for their relatives and friends. Some are even so corrupt as to accept bribes. Some people have engaged in favoritism in relation to housing, education, promotions, jobs, foreign affairs and so on. Some have used meetings to create an evil wind. There also has been an upsurge of individualism. People are wrapped up in the private interests of the individual and families. All of this shows weak leadership of the ministry's leading party group in ideological work in its organizations. The third is organizational impurities and lax discipline. This is most evident in the slowness and limited action in work to clear out "the 3 categories of people". At the same time, in building the "third echelon", ideology has not been opened up and the work has not been detailed and intensive. Lax discipline is an old problem and we still have not dealt with it in earnest. The phenomena of tardiness, quitting early and shopping during working hours are fairly severe. We have not dealt strictly with organizational life. Some people are extremely liberal, while others only implement the deployment and organizational decisions that they agree with and do not implement the others. We also do not have discipline in implementation. In some companies, bureaus, academies and institutes in the organizations, there are to a certain degree conditions with unclear rewards and punishments, no distinction between truth and falsehood, lax unity and poor work.

When he was examining each question, Comrade Gao Yangwen proposed measures for consolidation and reform. Lastly, he summarized the entire comparative examination and proposed four articles concerning the experiences and lessons we should absorb, the things that we should strengthen in the future and

what should be improved. The first is strengthening our study and understanding of the lines, principles and policies of the CPC Central Committee. Only if we have a deep understanding will it be possible to implement them with a high degree of consciousness, initiative and creativity. He said that, in looking at subjective desires, we all support and agree with the lines, principles and policies of the CPC Central Committee, and we wish to closely follow and assure identity with them. But why do we often feel that we cannot keep up, that our ideology is not open and that we cannot adapt to the demands the Central Committee places on us? The main reason is that our study is not earnest, our understanding is shallow and we fail to comprehend sufficiently the spirit. This is a very important lesson from experience. In the future, we must fully understand the essence of the lines, principles and policies since the 3d Plenum of the 11th CPC Congress. We must make liberation of our ideas, destruction of the old and creation of the new and opening up progress the starting point and foundation for ourselves when discussing major questions, thinking about problems and proposing measures. We can understand and grasp the entire situation only if we grasp this point. We are confined by "left" influences and restricted by following old customs. We cannot, therefore, destroy conventions and old restrictions and create new roads and a new situation. The second is that we must understand and creatively deal with our own professions. The third is that we must increase our knowledge and skills and solve the problem of the aging and relative narrowness of our knowledge. The fourth is that we have a spirit of searching for truth and a style of hard work. Any type of work should be concerned with implementation and emphasize practical results.

When the comparative examination ended, Comrade Gao Yangwen represented the ministry leading party group in displaying his determination to achieve the strategic goals proposed during the 12th CPC Congress. He said that it only requires that we consolidate the party well and earnestly implement the lines, principles and policies of the CPC Central Committee, have a spirit of inspiration, reform working styles, and do our work creatively and hard. If we do this, our strategic goals can certainly be achieved and the great cause of socialism and the four modernizations in the motherland can surely be successful.

12539

CSO: 4013/171

## COAL

### BUILDING 'LIANG HUAI' INTO ENERGY BASE FOR EAST CHINA

Beijing ZHONGGUO MEITAN BAO in Chinese 21 Apr 84 p 2

[Article by Ma Jilin [7456 0679 2651], first secretary of the Anhui Coal Industry Corporation Party Committee]

[Text] Liang Huai--the Huainan and Huaibei mining districts--is one of China's important coal bases. Prospecting results show that it contains deposits totaling 22 billion tons of coal spread over an area of 2,000 square kilometers. Its coal veins are thick, coal quality is good, and coal types found there run the gamut. Moreover, its location is not far from Shanghai, Jiangsu, and Zhejiang so it is in a strategic location. Both water and land transport are convenient, and it possesses excellent conditions for further development.

In the 30 years since the founding of our country, the Liang Huai area has constructed one after another a total of 22 pairs of mines with a designed capacity of 16.21 million tons. In 1983, the output of raw coal was 22.55 million tons. By the end of 1983, Liang Huai's total raw coal output had reached 439 million tons and 2.24 billion yuan in profits and taxes had been turned over to the state. This indeed constitutes a contribution to national construction. Since the Third Plenum of the 11<sup>th</sup> Party Central Committee, the scope of construction in the Liang Huai area has been further expanded and the pace of its construction has been quickened. Under the difficult conditions of thick overburden and quicksand layers, workers gained experience in sinking shafts by using new technology and techniques such as deep-shaft freezing, large-bore drills, composite shaft walls, and laterally moving towers. Out of this an engineering workforce has now been formed that is experienced in all forms of this work including expansion construction, basic construction, installation and specialty drilling. The workforce's qualifications and the level of its technical equipment have been greatly enhanced. Liuqiao, which is designed to produce 0.6 million tons of coal per year, Zhuxianzhuang, which is to produce 1.2 million tons, and Panji No. 1 Pit, which is to produce 3 million tons per year, have all gone into production. Work has officially begun on two mines designed last year--Xieqiao, which is to produce 4 million tons per year, and Taoyuan, which is to produce 0.9 million tons per year. In addition, construction is proceeding with great intensity on five pairs of mines: Pan No. 2, Pan No. 3,

Linhuan, Tongting, and Haizi. The total capacity of these ten pairs of mines is 19 million tons of coal per year. Construction on all sorts of auxiliary facilities and engineering projects is proceeding along with construction of the mines themselves.

The strategic plan advocated by the Party Central Committee and the State Council to develop Liang Huai and thereby change the tight energy situation in East China has placed Liang Huai on the list of the nation's key construction projects. With the help of a team of experts led by Professor Hua Luogeng [5478 5012 1649], we have set a long-range plan for the development of Liang Huai. We can confirm that by the end of this century a total of 23 pairs of mines will be constructed with a total capability of 48.7 million tons. This is equivalent to a three-fold increase over the design capability of the existing Liang Huai mining area. Add to this the output of the old mining area and one can see that the annual output of coal in the Liang Huai will reach 60 million tons; it will be a large-scale coal base with a real output triple that of current production. To realize this objective, we must first quicken our pace of reform and practice centralized, unified management toward manpower, finances, and materials and toward production, supply, and sales. We must make our corporation play its full role as an economic entity and enhance the enterprises' comprehensive economic benefits. Second, in our work we must give priority to the development of new districts and concentrate our strength on expediting construction of new mines. Third, we must promote the use of new technology, new techniques, and new equipment; we must elevate the mines' overall production capability and their capability to prevent disasters. We must raise the quantity and quality of our production. The political and technical qualifications of our ranks of staff and workers must also be raised. Meanwhile, we should actively support the construction of local coal mines. We must coordinate the development of washing and sorting and that of comprehensive utilization.

12668

CSO: 4013/161

## COAL

### ANHUI COAL INDUSTRY BROADENS INTERNAL-EXTERNAL COOPERATION

Beijing RENMIN RIBAO in Chinese 22 Apr 84 p 1

[Report from Hefei by RENMIN RIBAO correspondent Zhang Zhenguo [1728 2182 0948]: "Anhui Develops Local Coal Mines"]

[Text] Anhui has shattered the act of keeping mines in seclusion and working blindly behind closed doors, by implementing a policy of opening doors to outside mines, neighboring provinces, and foreign countries, and by applying measures to develop local coal mines with cooperative investments, joint ventures, and the joint household responsibility system with contracted work, in order to meet the imperative need of a vigorous development of the economy in the province. Adopted by the Anhui CPC Provincial Committee and the Anhui Provincial Government, this policy is targeted at the concrete conditions of this province's extremely rich coal resources and its acute shortage of local construction funds.

Step by step this policy is being carried into effect. Already started is construction of the Liuqiao Second Coal Mine, an Anhui-Zhejiang joint venture of cooperative investments, which has a combined output of 600,000 tons of coal. In the next 5 years, beginning this year, Zhejiang will provide 81 million yuan in construction funds; and in the next 10 years, starting this year, Anhui will provide Zhejiang with 3 million tons of coal as agreed upon. Also signed at an earlier date with the Ministry of Coal Industry and Fujian Province was an agreement on construction of the Tongting Coal Mine, a joint venture with a combined output of 900,000 tons of coal, the full-fledged construction of which is being started. The Ministry of Coal Industry and Fujian Province invested 15 percent and 50 percent of funds respectively, with Anhui accounting for 35 percent of the investment funds. Coal is divided in accordance with designed capacities and proportion of investments. In the past, this province had placed rigid limitations on the local small-scale mining of coal. This year, under the conditions of intensifying safety education and labor protection measures, they have permitted the running of coal mines not only by counties, towns, and villages, but also by a combination of the specialized households, which operate local and out-of-province coal mines. And so the number of small coal mines in counties and towns increased from 90 at the end of last year to more than 110 in the first quarter of this year. The opening up of coal mines by a combination of the specialized households is progressing by leaps and bounds.

In order to make Anhui's local coal mines develop strongly, they have recently broadened the horizon to foreign countries and are presently holding talks with foreign firms of the United States, Canada, and other countries, on development of the coal industry and on the use of foreign capital for building the Qinan Coal Field of this province.

12315

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## COAL

### YUNNAN SEEKS CORRECT POLICY TO MEET STATE'S DEMAND FOR INCREASED OUTPUT

Kunming YUNNAN JINGJI BAO in Chinese 6 Feb 84 p 3

[Article by Zhao Wei [6392 0251], Head of Yunnan Provincial Coal Department:  
"How Can Yunnan Coal Be Doubled?"]

[Excerpt] According to the needs of economic development in Yunnan and the mission of supporting other provinces, coal production in the year 2000 must be more than quadrupled as compared to that of 1983. However, the state of the coal industry in Yunnan is one of plentiful resources and good conditions coupled with low standards, low efficiency, and lack of adaptability. I believe that a correct exploitation policy and a set of practical policies are required to realize the aforementioned tasks.

As for the exploitation policy, we have already drawn up the correct policy to move on both feet, to combine large, medium, and small units, and permit the province, counties, and communes to advance together. The problem now is how to implement it. I believe that as we actively exploit prefecture and county state-run and small commune and brigade-run mines, we should also strive for several large projects to fundamentally alter the coal industry in Yunnan, and promote other sectors. One of these is the Xundian Vanguard open-cut brown coal [lignite] mine. This mine is located near a major coal consumption area--Kunming. It is only 35 kilometers from the railroad. The shipping-to-ore ratio is 3 to 1, and the coal quality is good. It not only can be used as a power fuel but also can be liquefied and gasified for civilian use. There is also diatomite, which is a light, temperature resistant, thermal insulating building material. The second is the expansion of the open-cut brown coal mine at in Kaiyuan. This mine already has an established productivity and the conditions for expansion are good. The third one is the Zhaotong open-cut brown coal mine, where reserves are abundant. It is hoped that this project will be officially studied in the first economic and technological collaboration leadership meeting of the three provinces in the southwest. The fourth one is the Enhong bituminous coal mine. The construction of this mine is an indispensable guarantee for the production of yellow phosphorus in Yunnan.

Since the Third Plenum of the Eleventh Party Congress, small coal mines in Yunnan have developed rapidly. Local and county (including commune and brigade) coal production has already reached 55 percent of the total in Yunnan. The exploitation of coal in Yunnan is still in a developmental

stage, especially in eastern and northeastern Yunnan where there are many coal outcrops. Furthermore, the potential to develop small coal mines is great because more excess rural labor becomes available the closer to the mining regions you get. However, the existing operation of small coal mines is irregular, safety and production conditions are poor, disaster prevention is lacking and the return on capital is low. These problems will have to be solved by formulating a set of practical policies and by strengthening the leadership--efforts to block these steps will not be tolerated. For example, they should be supported financially, as well as in terms of technological equipment to ensure safety and normal production. Investments should be made in those commune and brigade industries capable of carrying out technological reform. In order to solve the above problems, knowledge must also be exploited. We intend to establish a provincial technological training center to develop key local workers and major technical workers. In resource abundant areas, we should set up technical schools. Through reorganization of commune and brigade business, the management is gradually strengthened and profits will begin to accumulate. The present status of dividing up all the profits will be changed to benefit long-term, stable and healthy development.

12553

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## COAL

### EMPLOYING ADVANCED SCIENCE AND TECHNOLOGY TO IMPROVE MINE SAFETY

Beijing SHIJIE MEITAN JISHU /WORLD COAL TECHNOLOGY/ in Chinese, No 1, Jan 84 pp 4-9,53

/Article by Assistant Chief Engineer of Ministry of Coal Industry Zhao Quanfu /6392 0356 4395/: "Relying on Progress in Science and Technology to Improve Coal Mine Safety"/

/Text/ In order to thoroughly implement the decision of the 1982 National Coal Industry Planning Meeting to realize the "five changes" so that "the rate of improvement is stable, the development is healthy, the production is safe, and the economic benefits are good," we drew up the "Long-Range Safety Plan for the Coal Industry" which was discussed in the 1982 National Coal Mine Safety Workshop and the National Coal Safety Inspection Meeting held in April 1983. Requirements for the control of major disasters due to gas, coal dust, and fire to drastically reduce fatalities per million tons as well as to minimize the danger of dust were presented in the meeting. We clearly identified the new approach of a safety first, preventive, scientific and practical comprehensive treatment. Eleven major safety measures were formulated and implemented. In 1984 and the years to come, we must insist on following the new approach of safety in production. We have to work hard to implement all the safety measures in order to realize our goal.

#### 1. Taking the Approach of Scientific Comprehensive Treatment

Summarizing the experience in production safety in coal mines in China, more and more comrades clearly recognized that the comprehensive treatment of coal mine disasters with science and technology and the active adoption of new safety techniques are the necessary measures to reach safe production. However, some comrades still cannot realize its strategic significance. Especially when capital, equipment, and personnel are in short supply, they lose their faith in these measures. This indicates that it is also very important and urgent to strengthen our understanding of the new scientific and comprehensive treatment approach to learn and adopt new safety techniques by various means.

1. Realizing the Correlation Between Dependence on Science and Dependence on Management. Science covers a lot of ground. From the viewpoint of the coal industry, the realization of mechanization and

production automation depends on science and technology. However, both production organization and business management can be scientific or unscientific. Experience in production over the long run shows that scientific production organization and management can prevent accidents. Unscientific exploitation is one of the important causes of accidents. As for the safety technology itself, it has already developed into a special territory in science and technology. Its duty is to use scientific means, technical equipment, and scientific management methods to eliminate factors endangering the safety and health of personnel. It provides a safe and healthy working condition for production workers. Specifically, it is divided into safety engineering, industrial hygiene, and safety management engineering. They also include their own theories, as well as engineering and technological measures. In summary, relying on progress in science and technology itself includes scientific management, and institutionalizing management is scientific. The progress in science and technology can promote scientific management, while scientific and institutional management can also promote the development of safety techniques.

2. Science and Technology--Productivity as well as Disaster Resistance. Safety has always been an extremely important problem concerning the development of the coal industry and protection of employee safety and health. As full mechanization of extracting, digging, shipping, and supporting is realized in excavation, roof accidents are basically prevented. With the development of electronic and telecontrol techniques and their applications in coal mines, we are able to continuously monitor gas and set off alarms when the threshold is exceeded. Power will be automatically cut off to basically control gas accidents. On the other hand, as excavation becomes more mechanized and automated, the mine becomes deeper, leading to a drastic increase on the amount of gas present. The amount of powdered dust generated increases. The number of mechanical and electrical fire alarms will rise. In order to ensure production safety and to protect expensive machinery and equipment, it is also necessary to use corresponding new techniques for fire prevention.

3. Implementing Comprehensive Treatment. Broadly speaking, comprehensive treatment means handling the problem by various methods, such as strengthening the leadership and the ideological work, enforcing organizational discipline and business arrangement, adopting new safety techniques, and executing a merit system. In terms of science and technology, a comprehensive technical treatment will be used based on accident patterns so that nothing will be missed in the future.

## II. Changing the Outlook of Mining Technology

It is necessary to drastically change the outlook of mining technology in order to take the approach of relying on scientific, comprehensive treatment. The most important technological base for production safety of coal mines is to realize mining mechanization and automation, quality standardization, and production regularization.

1. Increasing the Extent of Mechanization and Automation. By summarizing the experience in the world, fatalities per million tons has decreased significantly, mainly attributed to the high degree of modernization of mining and mechanization of excavation. The apparent effect is that the number of workers in the mine is greatly reduced which lowers the probability of accidents and the number of casualties per accident. Secondly, combining mining with excavation can eliminate roofless and hazardous operations. It fundamentally prevents roof accidents, which account for 40 percent of coal mine accidents. Thirdly, the production techniques are simplified to reduce the amount of physical labor, which allows the miners to concentrate on production safety in other processes. Therefore, we must consider increasing the degree of excavation mechanization as an important design standard for new mines under construction. The degree of mechanized excavation and extraction must be above 70 and 45 percent, respectively. This promise should be honored in production mines based on the organizational plan. Thus, the number of deaths in coal mine accidents can be reduced by 25 percent by 1990.

2. Increasing Disaster Resistance of Mine Production System. The design of new mines must be rational and simple. A single conveyor system should be used in the transportation system. A simple parallel zoned ventilation system should be used in the ventilation network. Lane support should be made permanent. New technologies, techniques, and equipment should also be used to improve the resistance of the transportation, drainage and power supply systems to disaster. Safety measures and worker protection devices against gas and coal dust explosions, fire, and flood must meet the requirements for mine safety devices. They should be used as production begins, otherwise, production should not take place. Automatic monitoring devices must be used in systems such as production operation, lift transportation, ventilation safety, gas pumping and water drainage. Producing mines must be technologically modified in order to gradually reach the aforementioned requirements. The amount of work in mines should be minimized in the production process to significantly decrease the number of workers to reduce the probability of accidents in the pit.

3. Realizing Mining Quality Standardization. Historical experience in coal mining proves that the quality of engineering, equipment and devices, and work is very important to production safety in coal mining. "Quality is the lifeblood." Therefore, it is necessary to implement the policy that quality is number one. Quality standards must be determined for various engineering, equipment, and devices involved in coal production. In terms of basic construction, the quality of the excavating face, engineering of ventilation equipment, installation of electrical devices, and maintenance of lane support must be strictly inspected. Unqualified work will not be accepted. Good work will be praised and bad work will be punished. An overall quality control system must be established to initiate a quality standardization work so that the mines will meet the quality requirements.

4. Insisting on Regularization of Mine Production. Coal mine production is a complex and dynamic process. It consists of the main production work as well as a great deal of preparation and supplementary work. All must be coordinated according to a sequence and the activity of each outfit must be consistent. Hence, there is need for a program which coincides with the production pattern. For example, excavation work must be done according to plan to proceed with organizing the design, formulating operating manuals and safety measures, and implementing training programs. A routine mine production chart will be prepared around these procedures in order to provide accurate instructions. Our experience shows that safety can be maintained by insisting on operating according to the manuals and charts. Safety cannot be assured when production is carried out randomly without a plan, which will lead to many accidents. Therefore, we must work hard to organize and insist on the regularization of production. Every safety item must be included in the routine operating chart in order to establish a safe production sequence.

### III. Adopting New Safety Technology With Enthusiasm

New safety technology will be widely adopted. Treating disasters scientifically is an important policy to be implemented by the coal industry for production safety. According to the actual situation of coal mines in China, the emphasis should be placed on the prevention of three major disasters of gas, coal dust, and fire, as well as incidents involving the roof and transportation which occur frequently. Based on the lessons learned over the years, the key new safety techniques adopted in 1984 should be focused on the prevention of gas and coal dust explosions at the tunnelling face, fire hazards due to internal and external causes, and danger of dust and roof accidents.

1. New Techniques Used To Prevent Gas and Coal Dust Explosions at the Tunnelling Face. Seventy percent of the gas and coal dust explosion incidents occur at the tunnelling face. In 1983, however, 90 percent of the gas explosions took place at the tunnelling site. Especially when tunnelling is done mechanically at high speed, the amount of gas emitted increases, becoming more hazardous. When the amount of gas present reaches  $3-15\text{m}^3/\text{min}$ , the air supply required is  $300-1,500\text{m}^3/\text{min}$ . Therefore, the prevention of gas and coal dust explosions during tunnelling should be handled as a focal point in the 1984 safety work. It mainly involves the use of new safety techniques available in the world to provide a comprehensive prevention on the basis of strengthening management in planning, technology, construction, and ventilation.

(1) Improving Reliability of Local Ventilation by Using Double Source Dual Local Fan Automatic Switching Devices. Two sets of local fans with two separate power supplies were used at tunnelling sites where the amount of gas was large in Pingdingshan 5th, 7th and 1st mines. Furthermore, an automatic switching device was developed to automatically start up the other fan when a fan or power source is not working. Thus the danger

of gas accumulation and the need for gas discharging due to the breakdown of a local fan can be prevented. The tunnelling work can also proceed with some assurance, leading to safe, fast results.

(2) Adopting Means To Monitor Safe Operation of Local Fans and Measure Air Speed at Outlets. The fan is monitored through vibration. Defective axle and blades of a fan can be detected by the variation of its vibrational frequency. An alarm will be sounded at the dispatch room on the surface to handle the matter in time. Anemometers will be installed at the outlet of the duct and in the lanes. When the actual rate has dropped to a dangerous level, an alarm will be sounded.

(3) Using a Comprehensive Gas Pumping Technique for Coal Beds With High Gas level. Holes will be drilled into the bed to be tunnelled in order to pump the gas out ahead of time through dedicated gas lanes or neighboring lanes. During tunnelling, holes drilled can be used to pump gas as digging progresses. High negative pressure, constant flow rate gas pumps must also be imported, to handle long-term pumping at high negative pressures with densely drilled holes in order to solve the gas problem.

(4) Installing Automatic Gas Monitoring Systems and Gas Breech Systems. When the drilling fan stops and the cumulative gas exceeds the limit in the tunnel, power is cut off. The ventilating fan cannot be started again. It is necessary to draw up safety measures to bypass the breech in order to remove the gas and prevent gas explosion incidents caused by the casual discharge of gas.

(5) Adopting New Dust Prevention Equipment and Summarizing Dust Prevention Measures. The concentration of dust inhaled will be reduced to below  $2\text{mg}/\text{m}^3$  by using the wet electric coal drill manufactured by the Tianjin Coal Mining Special Equipment Plant, promoting sonar activated automatic water spray curtains adopted by some mines, importing dust removal and exhaust fans from England, and implementing a combination compression and exhaust ventilation system.

(6) Controlling Sources Igniting the Gas at the Work Face. A comprehensive protection system must be installed on the entire power supply system at the tunnelling site. A smoke and fire alarm system must be installed in the tunnel. Highly safe emulsified oil explosive must be used in blasting. Fire hydrants and standpipes should also be installed to effectively control and extinguish any fire.

(7) Using New Measures To Suppress Gas and Coal Dust Explosions. A gas explosion at the tunnelling face frequently leads to a coal dust explosion, compounding an accident. To this end, in addition to spreading rock powder and installing explosion isolating rock powder and water mats we must also develop an automatic explosion isolating water mat. Once the gas begins to burn or explode, the incident can be controlled in a localized region near the tunnelling site.

In order to implement the aforementioned measures, we must organize scientific research institutions, factories, and coal mines to jointly develop and manufacture devices as we equip a sample tunnelling work face in 1984.

2. Adopting New Fire Extinguishing Techniques. Spontaneous fire is a serious problem in coal mines. More than 48 percent of the mines have the danger of spontaneous combustion which seriously threatens production safety. In 1983, fire due to external factors such as electricity, plastic belts, and machinery was also serious. Therefore, now fire extinguishing techniques must be used in 1984. Fire prevention work also must be strengthened.

(1) Promoting Comprehensive Fire Prevention and Extinguishing Techniques. When excavating any coal bed with the danger of spontaneous combustion measures such as grouting, spraying retardant, isobaric ventilation, and enclosing excavated areas must be used to prevent spontaneous fire. The same methods should be used to eliminate existing fire hazards in order to liberate the coal located in these areas and to ensure production safety.

(2) Using New Fire Prevention Techniques To Solve Columnless Coal Excavation Problems. In many coal mines in China, measures such as columnless lane excavation and land reservation are implemented in order to achieve higher recovery, reduced lane pressure, and lower tunnelling rates. However, because excavated areas were not isolated, incidents such as spontaneous fire and sudden gas eruption occurred. For this reason, face walls must be built to isolate excavated areas to prevent fire, i.e., to build a stone wall of a certain thickness between the air return way and the scraper--trough conveyer. Furthermore, a "mono" pump is used to deliver clay made of plastic uncoagulating slurry to the stone to form a wind barrier to prevent air flow from entering the excavated areas.

(3) Using Liquid Nitrogen in Fire Prevention. There are many oxygen producing facilities in China. During the oxygen production process, a lot of nitrogen is released. If this nitrogen is recovered, liquefied, and delivered to mines on specially designed tank cars, it can be delivered to an excavated area with spontaneous fire faces and sealed lanes by pipes to provide a fire prevention effect that grouting cannot achieve. The long-range fire extinguishing by liquid nitrogen and inert gas generators can also effectively prevent any gas explosion caused by fire. From 1984, all the rescue teams under the mining bureau must be equipped with 200 m<sup>3</sup>/min high-power fire extinguishers and 150m<sup>3</sup>/min inert gas generating devices. In addition, inert gas generating devices capable of producing 100 m per minute should be introduced to experiment with the use of nitrogen in fire prevention.

(4) Strengthening Fire Retardation of Belts. Each year 1.20 million meters of conveyor belts are used in China, of which 900,000 meters are

not fireproof. Belt fires have become a major source of disaster in mines. In addition to strengthening management, preventing blockage, and perfecting firefighting equipment, it is necessary to take the following measures to fundamentally prevent belt fires.

Organizing to Manufacture Fire-resistant Belts. The plants in the ministry will be required to take the proper measures to increase production of fire-resistant belts in 1984. The inspection of the fire-resistance of the belts must also be intensified in order to facilitate the switchover by a batch process.

Using Belt Fire Monitoring Devices. It is proposed to import a comprehensive conveyor belt monitoring and protection system for belt shipping, blocking, and tearing, bearing temperature, brake temperature, axle temperature, and smoke detection. Furthermore, we will initiate our own development.

Installing Fire Fighting Equipment. Most belt fires occur at the nose rollers. Therefore, sprinklers should be installed in the vicinity to be automatically activated when the temperature rises or a fire is started by friction.

3. Establishing Mine Safety Monitoring Systems. In order to prevent gas explosions and fire incidents due to internal and external causes, it is necessary to establish mine safety monitoring system with the following capabilities: 1. continuously monitoring gas (at high and low concentrations) to provide a threshold alarm, to cut off electricity and to send the information to the surface; 2. forecasting fires, monitoring carbon monoxide, and sending the information to the surface; 3. providing fire and smoke alarm due to external causes and extinguishing fires automatically; 4. continuously monitoring air speed and pressure at the work faces in mines; 5. monitoring the operating conditions of the main and local fans, including bearing temperature, power, vibration, and air pressure; 6. monitoring and controlling major air doors to shut off backup air doors automatically to prevent the short circuiting of air flow when an air door is left open or damaged; 7. monitoring impact crustal pressure and gas using crustal acoustic and microseismic devices; monitoring the dustproofing system, including detecting the water pressure and flow in the waterpipe, water flow in the automatic sprayers and the dust concentration; 9. safety monitoring of the concentration, temperature, and negative pressure in gas pumping; and 10, providing communications for personnel dispatch and emergency alarm systems for mines.

Today, mine safety monitoring systems such as the Japanese 7000 series systems, the British MINOS systems, the American SCADA systems, the West German Geamatic 2000i automatic systems, the French Model CTT63/400 centralized monitoring systems, and the Polish Model CMM-20 and Model CMC-1 digital systems which imitate the French system, have been gradually developed by using telemetry, telecommunications, and remote control. These systems have their advantages and disadvantages, however, they are effective in monitoring the safety of mines.

In order to establish coal mine safety monitoring systems in China, we imported some safety monitoring devices to be installed in a number of mines to accumulate experience and to train people. In the meantime, safety monitoring technology is being introduced to create a coal mine safety monitoring system in China and to build the capability to manufacture such devices. The Chinese-made safety monitoring devices will be produced in large quantities to equip a number of mines for gas monitoring. The principles of installing such devices are: 1. to equip mines with gas, serious threat of spontaneous fire, and high degree of mechanization with multi-parametric comprehensive safety monitoring systems; 2. to install air flow, carbon monoxide, and external fire detectors in highly mechanized mines with methane and the threat of spontaneous fire; 3. to equip mines with methane but without or with little threat of spontaneous fire with methane and external cause fire detectors; 4. to install accident alarm systems in mines with key equipment; 5. to use the same type of equipment in the same bureau to the extent possible in order to facilitate maintenance control; and 6. to install fixed telemetric or power cutoff devices in excavating areas with a high content of methane.

In order to immediately equip mines with serious gas and fire hazard with effective safety monitoring systems, each mine must prepare an equipment design. Installation is not permitted without such a design or without approval. A team of professionals with at least 15-20 people must be organized and led by an engineer and technical training must be well organized. The Institute of Mining is responsible for training in imported systems and the Shanxi Institute of Mining is responsible for training in Chinese-made systems. Without training, the system cannot be installed and used. The production of Chinese-made safety monitoring systems and accessories must be well organized. A set of operating, maintenance, and repair systems and regulations must be established.

4. Using Domestic and Foreign Dust Proof Technologies to Control the Dust Hazard. The hazard of coal mining dust is very serious. Coal mining dust lung disease and coal dust explosions are not yet controlled in China. Therefore, the following new dustproof techniques must be adopted to form a complete set in order to control all the hazards due to dust.

(1) Promoting Coal Bed Water Injection Technique. Injecting water into coal beds should be adopted at all excavating sites. All mechanized faces must use water injection in 1984. The present drilling machine and other water injecting equipment must be improved to permit water injection through long holes from the air returnways and scraper-trough conveyor lanes in order to eliminate the effect of water injection from the work face on production and to resolve the problem of poor water quality.

(2) Using Wet Drilling. Wet drilling must be adopted for tunnelling through rock. Wet-type electric coal drilling should be promoted in coal lanes. The dry-type drilling should be avoided as soon as possible by resolving all the problems in wet drilling.

(3) Using Dust Removal Fans. The Zhenjiang plant is manufacturing dust removal fans. It is also planned to purchase some dust removal fans and explosion-proof exhaust fans to equip the excavation faces.

(4) Adopting New Dustproof Techniques for Excavators. A dust capturing device involving the use of suction to capture dust in hollow rollers and a water sprayer system will be used on coal excavators. Pressurizing pumps will be used to solve the water pressure problem associated with a dustproof excavator. Excavating equipment purchased abroad must come with dustproof devices.

(5) Expanding the Use of BZSE Explosion-proof Automatic Sprinkler Control System Manufactured by the Jiamusi Explosion-proof Electrical Appliance Plant. The system can be installed at loading points, transfer points, coal yard entrances and coal conveyor systems, as well as on the ventilating system for the mine. This device has been operating at Shuangyashan and Xinwen with good results.

(6) Pursuing New Individual Dustproof Device Developed in China. Use the Model AFM-1 dustproof caps, explosion-proof blower masks and Model AYH-1 compressed air respirators as mandatory protective equipment for excavator operators and other workers.

(7) Organizing the Development and Construction of Automatic Detectors for Breathing Dust and Purchasing 60 Such Devices To Equip Some Mines in Order To Perfect the Dust Monitoring Means.

(8) Adopting Comprehensive Measures To Suppress Coal Dust Explosion. In addition to spreading rock powder and establishing rock dust and water shields, it is also necessary to develop a fire extinguisher which can be automatically triggered by an explosion wave sensor. We will also develop gas and coal dust explosion suppressing devices such as automatic sprinklers or fire extinguishing powders which are initiated by thermocouple flame detectors and powered by compressed nitrogen.

#### IV. Accelerating Scientific Research on Safety

There are many reasons why the coal mine safety technology in China is lagging behind. Some are historical and some sociological. However, the backward scientific research means is also an important cause. We must use new methods and new approaches to accelerate the scientific research on safety to rapidly convert research achievements into productivity.

1. Using Comprehensive Research To Improve Overall Disaster Resistance. A comprehensive research effort on safety is to conduct studies on mine pits, excavating faces and mining electrical equipment in order to adopt technical measures to improve the overall disaster resistance. It involves investigations on the hazards of gas, coal dust, and fire in

order to implement an overall treatment. The scientific research of mine pits as a whole is to study the excavating mode, production system, coal extracting method and safety technology in order to provide a highly mechanized, automated, systematic, simple and reliable technological base fully equipped with safety devices. The scientific research on the excavating face as a whole is to accomplish the objective of comprehensive disaster treatment to improve the overall disaster resistance by conducting complementing research in the areas of ventilation, gas pumping, safety monitoring, comprehensive dustproofing, fire control and explosion suppression. The scientific research of mining electrical and mechanical equipment as a whole is to make the equipment itself explosionproof, fireproof, dustproof, and mechanical damage resistant.

Improving the dustproof capability of coal extracting machines is set aside as a topic in the comprehensive scientific research because gas frequently builds up in the holding tank and then ignited by sparks created by friction between gears or rocks when the dust concentration in the air reaches  $2\text{mg}/\text{m}^3$  at the work face due to insufficient spraying. A suction roller and a hollow dustproof roller were developed through scientific research. A suction roller uses nine hydraulic dust capturing tubes in a roller which suck in gas containing large amounts of coal dust and methane on the work face side. A high-pressure conical hollow water sprayer is installed in the dust capturing tube. It is not only capable of injecting air but also can capture fine coal dust with high efficiency. This device is noiseless and has no moving parts. It is integrated into the coal extraction as one entity. A hollow roller uses a high-pressure water nozzle on the inlet of a hollow tube in the roller of a coal extractor to create a certain negative pressure in order to introduce a fresh air flow from the other side towards the coal wall to dilute the gas near the roller and to remove dust. In order to conduct studies on preventing gas ignition by friction sparks, England established a special simulation laboratory. It was discovered through experiments that sparks created by the friction between copper and rocks could also cause gas explosions and combustion. Consequently, there was no way to find a solution in materials. A method was subsequently discovered to spray water in front of the hollow gears to prevent sparks and capture dust. The use of a gamma detector was studied to prevent the coal extractor from cutting the top and bottom plates to avoid sparks due to friction. In the research of fire extinguishing techniques for coal extractors, fire sensors were installed on coal extractors and fire extinguishing devices were placed near the roller. Once the gas begins to burn, the sensors will automatically activate the fire extinguishing devices to put out the fire. In studies on mechanical injury from coal extractors, most injuries at the excavating face are due to drive chains and personnel falling under the machine. For this reason, the chain drive system should be replaced by a chainless one. Furthermore, an infrared protection system should be installed near the coal extractor to automatically shut off the machine as people enter the danger zone. Various sensors and

microprocessor monitoring devices are used in the studies of the operation and breakdown protective devices of coal extractors to monitor the operating conditions such as coal dust, hydraulic pressure, power supply, cutting, driving, and temperature protection systems. An alarm will be sounded once a breakdown occurs and the machine will be shut down with a delay. The breakdown will be handled in time through a display system.

In order to accelerate scientific research on safety, it is necessary to initiate a collaborative effort. First, an overall plan must be organized by the Institute of Safety Research with related research institutes, plants, coal mines, and schools. Scientific achievements which have successfully been applied should be promoted. Those not yet used in practice should be tried out by finding the problems and the causes. With regard to research projects in progress, we must determine priorities and attack them. Secondly, a collaborative research network must be formed to implement the key research projects by organizing the research institutes, plants, schools and mines inside and outside the ministry. Several safety research groups will be created to implement the key research projects to begin a full-scale war in safety research. Thirdly, the method and policy of safety research collaboration will be drawn up and a development contract system will be created. Each research project will have principle demonstrating experiments, whole unit testing, complete revised design, product specifications, various certifications, and inspection. Qualified projects must be manufactured to be listed as a scientific research achievement.

2. Conducting Applied Research by Adopting and Referring to Domestic and Foreign Advanced Technologies. Through safety technology investigations, many foreign coal mines conducted safety research on applying electronic, remote sensing computer, machine manufacturing, and environmental protection techniques to coal mines through collaboration with industries such as defense, aeronautics, chemicals and machine building. The safety research institutes in the U.K. and the U.S. manufacture many mine safety devices in collaboration with plants with advanced technological equipment.

In order to raise the Chinese level of research and safety equipment to modern standards, we must concentrate on applied research to produce copies. The safety research plan must be adjusted to put the research effort on digestion of and applied research on newly introduced techniques and devices by combining creation with imitation. There are five focal points, i.e., safety monitoring techniques, ventilation to prevent gas, pumping and burstproof techniques, new techniques and devices for dustproofing, new equipment, measures, and materials to prevent and extinguish fires, and mining machinery and electrical safety technology. China has already imported equipment in the five areas mentioned above. The research institutes, importing units, plants, and schools must be organized to collaborate to digest, study, manufacture, and apply these technologies.

In addition, advanced techniques and research achievements obtained by the defense aerospace, fire fighting, chemical, machine building and electronic industries should be understood thoroughly by organizing an effort to conduct investigations or to hold discussion meetings. An application plan should be drawn up to organize collaborative research or manufacturing of devices.

3. Adopting Advanced Research Techniques. In order to make safety research achievements reach an advanced level within a short period of time effectively, the Institute of Safety Research must be comprehensively planned and totally recognized. It should adopt advanced research means.

(1) Research laboratories for explosions, mine rescue, lifting transport, and electrical safety should be established and improved.

(2) Simulated experiment sites and mines must be built to resolve the contradiction between research and production. To accelerate the pace of research, the Shengli Mine at Fushun will be converted into an experimental mine. Experimental lanes for fire, explosions, and ventilation, sites for mining machinery and electrical equipment, and simulated spark test facilities will be built.

(3) Computers for research applications will be introduced. Safety research equipment and instruments will be acquired to raise the research efficiency.

(4) Technical cooperation will be established internationally with research outfits to reform the existing research institutes, train research personnel, and improve the research standard.

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CSO: 4013/117

COAL

LARGE COAL DEPOSITS FOUND IN GUANGXI

OW200914 Beijing XINHUA in English 0726 GMT 20 Jun 84

[Text] Nanning, 20 Jun (XINHUA)--Large coal deposits with verified reserves exceeding 400 million tons have been found in the You-Jiang Basin in western Guangxi Zhuang Autonomous Region.

The reserves are the largest ever found in the coal-short region in south China. Mining of these reserves will help increase coal supplies to Guangxi and other regions south of the Yangtze River, which get most of their coal from the north.

Geologists exploring minerals in the basin in the past 5 years have also found large deposits of bauxite and bentonite.

It was reported that the bauxite found was of high grade and there was a 7-to-8-meter thick deposit bed suitable for open cutting.

CSO: 4010/110

COAL

MAJOR COAL MINES MEET MID-YEAR TARGETS

OW270844 Beijing XINHUA in English 0810 GMT 27 Jun 84

[Text] Beijing, 27 Jun (XINHUA)--China's major coal mines reached their January-June production target on Tuesday by digging out 193.12 million tons, 4 days ahead of schedule, the Chinese Ministry of Coal Industry said here this morning. Production was up 5.3 percent on the first half of 1983. Plans for dressed coal and tunnelling were met 15 and 16 days ahead of time respectively, the ministry said. China has 1,834 coal mines divided into two categories: major mines, the larger ones with output distributed by the state and large numbers of small and medium-sized pits run by various localities. The locally-run mines, which produce nearly half of the national total, also expect to complete their January-June production plans ahead of time, the ministry said. Coal Ministry officials expect this year's total output to top the 710-million-ton target set by the government. Coal provides about 70 percent of the country's energy needs, and China is now the third largest coal producer in the world, next to the Soviet Union and the United States.

CSO: 4010/115

COAL

#### BRIEFS

HEILONGJIANG LOCAL COLLIERY PRODUCTION--Local collieries in Heilongjiang Province prefulfilled the semiannual production plan for 1984 by 26 days. As of 30 June, these collieries had produced 7.4 million tons of raw coal, an increase of 1.4 million tons over the corresponding period in 1983. [Excerpts] [Harbin HEILONGJIANG RIBAO in Chinese 12 Jul 84 p 1 SK]

NEI MONGGOL COAL PRODUCTION--In Nei Monggol, collieries whose products are distributed under unified state plan prefulfilled by 4 days their semiannual raw coal production target. By 30 June, they had produced 4.04 million tons of raw coal, 3.2 percent over the corresponding 1983 period. The Baotou and Wuda Coal Mining Administrative Bureau were the best in the production. [Text] [Hohhot Nei Monggol Regional Service in Mandarin 1100 GMT 4 Jul 84 SK]

SHANXI LOCAL COLLIERY PRODUCTION--As of 20 June, local collieries of Shanxi Province had produced 18.4 million tons of coal, prefulfilling by 10 days state-assigned semiannual target and registering an increase of 7.69 percent over the same period of last year. [Excerpt] [Taiyuan SHANXI RIBAO in Chinese 2 Jul 84 p 1 SK]

SHANXI COAL PRODUCTION--In Shanxi Province, collieries whose products are distributed under unified state plan prefulfilled by 5 days their semiannual raw coal production task. As of 26 June, they had produced 39,079,300 tons, exceeding the target by 259,400 tons and registering a 7.3-percent increase over the same period of 1983. [Text] [Taiyuan SHANXI RIBAO in Chinese 27 Jun 84 p 1 SK]

JILIN COAL PRODUCTION--As of 24 June, the Dongbei and Nei Monggol Coal Industrial Integrated Corporation had overfulfilled the semiannual raw coal production target 6 days ahead of schedule. In the first half of this year, this corporation produced 2.6 million tons more of raw coal than in the corresponding 1983 period. [Excerpt] [Changchun Jilin Provincial Service in Mandarin 1030 GMT 26 Jun 84 SK]

CSO: 4013/203

ON FORMATION OF OIL FIELDS IN CONTINENTAL BASINS IN CHINA

Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese Vol 4, No 3, Jul 83  
pp 1-11

[Article by Zhang Wenzhao [1728 2429 2507] of the Geological Exploration  
Company of the Ministry of Petroleum Industry]

[Text] Abstract

The characteristics of oil and gas migration and accumulation and the general rules regarding the formation of large oil fields in China's continental basins are the main subject of discussion in this paper. Short distance lateral migration of oil and gas is the general rule, though vertical migration and multi-stage accumulation and dispersion are not uncommon. The height of vertical displacement controls the upward migration of oil and gas, and primary oil pools are formed in the lower part of the main faults and secondary pools in their upper part. In our continental basins, there are three types of oil pools with: oil generated and reservoired in rocks of the same age, oil generated in young source beds but reservoired in old rocks, and oil generated in old source beds but reservoired in young rocks. The prerequisites for the occurrence of a large oil field are: an oil generation sag, a large trap, a large sand body (or similar reservoir), an unconformity surface and a large contemporaneous fault.

Preface

The continental sediments of Mesozoic and Cenozoic basins in China are world famous. A large group of large and medium-sized oil and gas pools and various types of oil and gas reserves have been discovered in these basins, with an annual yield of as much as 100 million tons of crude oil. The formation and distribution of the oil and gas reservoirs in continental basins have their own special characteristics, as well as their differences from marine oil and gas pools. This article will provide preliminary summaries of practice in exploration in recent years, of the special characteristics of oil and gas migration and accumulation in continental basins, and of the formational conditions and regularities in the rich accumulations of large continental pools.

## I. Geological Background for the Formation of Oil and Gas Pools

During the Mesozoic and Cenozoic periods, the Chinese continent was affected by the underthrust of the Pacific plate toward the Eurasian continent and the thrust of the Indian plate toward the continent. This formed a continental framework of alternating depressions and uplifts. The depressions received deposits primarily from Mesozoic-Cenozoic facies and formed sedimentary basins of various sizes and types. Bounded by Helan Shan, Liupan Shan and Longmen Shan going in a south to north direction, the eastern part of China was formed primarily of extension basins caused by block-fault movement on a background of regional settling. The basins spread out in a NNE direction with an alternating sequence of depressions and uplifts. There are five successive subsidence zones going from west to east: the Erlian--Ordos--Sichuan subsidence zone, the Songliao--North China--Jiangnan subsidence zone, the Yellow Sea--Northern Jiangsu subsidence zone, the western East Sea subsidence zone and the eastern East China Sea subsidence zone. The subsidence zones are separated by uplifts. Moving from west to east in the basins, the oil formation period becomes more recent, the degree of subsidence increases, and there are stronger crustal movements and volcanic activity. The western part of China has compression basins formed by folding movements on a background of regional uplifts. The basins spread out in a WNW direction, with alternating depressions and rises. There are three main subsidence zones running from north to south: the Junggar subsidence zone, the Tarim--Turpan--Hexi Corridor subsidence zone, and the Qaidam--Gonghe subsidence zone. They are separated by folded zones. Tectonic activity in the basin becomes stronger going from north to south. This illustrates the importance of the Pacific and Indian plates in the formation of continental basins in China. The Mesozoic-Cenozoic basins have the special characteristics of multiple cycles. During their formation and development, the basins went through stages of upward arching, faulting, subsidence and shrinkage. The upward arching period was the era of basin occurrence. The faulting and subsidence periods were the period of oil formation in the basins, and the shrinkage period was the period of basin withering. The basins developed unevenly during these four periods, which led to the differences in oil formation in the basins.

During the faulting and subsidence periods in the basins, unconnected and numerous lakes of various sizes developed on the continent. There were mostly inland lakes in the western part and nearshore lakes in the eastern part. There were short temporary marine transgressions and lagoonal facies sediments. Oil and gas were generated mainly within lacustrine deposits. The large numbers of continental facies freshwater biota show that the lake basin sedimentary facies assumed a ringlike spreading out shape. The source rock has the special geochemical indicators of continental facies types, and the crude oil has high paraffin, sweet characteristics. This is evidence of oil formation in continental facies sediments. The continental basins of China also are characterized by large-area water bodies, long periods of development, deep subsidences and a high ground temperature gradient. They were, therefore, quite favorable for oil and gas formation. The separation of the continental basin deposits and the multiple periods of crustal movement gave them the special characteristics of multiple source areas, nearness

to source areas, multiple inlets, steep slope grades, rapid accumulation and multicycle sedimentation. The basins also have different sedimentary environments and types of accumulating bodies in the oil horizons. There are alluvial cones in the piedmont environment of the Karamai oil field on the northern edge of the Junggar Basin. The plains environment of the Ordos Basin has plain and river bed sand bodies and marshy braided and convex lens-shaped sand bodies. In the Songliao and North China Basins in the eastern part of the country, there are widespread littoral environment lake basin delta systems (meander deltas and fan deltas), as well as the derived river-mouth bars, sheet sands and underwater tributary channel deposits. The rudaceous rock (oolitic and biogenic beaches) formed turbid sand bodies. The sediments of these different environments determined the accumulation types and special characteristics of oil and gas pools in the continental basins. A large amount of exploration practice has proven that most of the lakes in the continental basins were source areas. The lake boundaries are areas of rich oil and gas accumulations, and the main oil pools occur on both sides of lake strand lines. Defining the lake strand lines in ancient lake basins is an important topic in research on the paleogeography of sediments and in oil exploration on continental facies.

## II. Oil and Gas Migration in Continental Basins

The continental basins are characterized by short distance lateral migration. It has been determined through analysis of the properties of the fluids, the normally-structured alkane hydrocarbons of the crude oil and other indicators related to migration that the migration distance of oil and gas in the continental basins of China usually ranges from a few kilometers to 30 kilometers (Table 1).

Table 1. Statistics on the Distance of Lateral Oil and Gas Migration in the Continental Basins of China

<u>Name</u>	<u>Distance of Oil and Gas Migration (in kilometers)</u>	
	<u>General</u>	<u>Greatest</u>
Songliao Basin	0-40 (approx)	--
Ordos Basin	0-40 "	60
Jiyang Depression	0-20 "	30
Liaohe Depression	0-20 "	30
Huanghua Depression	0-20 "	30
Yizhong Depression	0-20 "	30
Jiangnan Basin	0-10 "	15
Nanyang Basin	0-10 "	20
Jiuquan Basin	5-20	50
Junggar Basin	30-50	80

The central depression of the Songliao Basin is an oil generating region which underwent continued subsidence over a long period: the source rock can be as thick as 1,000 meters. The basin is surrounded by weak uplifts and there are small differences in underground hydrodynamic pressures. The

sandstone bodies thin out toward the center, and the basin has no water outlet. This formed the hydrogeologic conditions for stagnation. Various geochemical indicators and changes in the nature of the crude oil moving from the center of the depression toward the sides show clearly that the oil and gas from the Gulong and Sanzhao depressions migrated in the direction of Daqing and Changyuan (Table 2). The maximum oil and gas migration distance is less than 40 kilometers. This type of short-distance lateral migration in a continental basin is in obvious contrast to the long-distance lateral migration covering several hundred kilometers in marine facies sedimentary basins. The primary geological factors which led to short-distance lateral migration are the complexity of the sediments and structures in the continental basins and the relatively stagnant hydrodynamic conditions. The complexity and variability of typical sediments in the continental basins formed heterogeneous sand body distributions. The segmentation by faults and the eluvial water forces at the periphery of the basin restricted oil and gas migration.

Table 2. Changes in Geochemical Indicators of Lateral Oil and Gas Migration from the Source Depressions on Either Side of Daqing and Changyuan

<u>Direction of Migration</u>	<u>Normally- Structured Alkane Content (percent)</u>	<u>Isoprene Alkane Content (percent)</u>	<u>Relative Iron Content</u>	<u>Relative Nickel Content</u>
Gulong → Changyuan	36 → 21.7	2 → 1.37	66 → 25	37 → 25
Sanzhao → Changyuan	27.3 → 19.6	1.6 → 1.1	88 → 7	36 → 29

(Based on data compiled by Yang Wanli [2799 8001 6849]).

One of the common regularities of oil and gas migration in the petroliferous basins is the multidirectional migration of oil and gas from the deep source depression toward the low-pressure regions around the basin. The migration of the oil and gas from the deep depressions toward the periphery was not uniform, however. The oil and gas often migrated quite actively and on a large scale in a particular primary direction. This direction was toward the uplifted side of structural movements that occurred during the oil formation period, and is coordinated with large sandbody facies. For this reason, most accumulations in the continental petroliferous basins are concentrated in one or two structural zones. Daqing and Changyuan contain 87 percent of the petroleum reserves in the Songliao Basin. The Shengtuo and Dongxin structural zones contain 63 percent of the petroleum reserves in the North China Basin's Dongying depression. The Wangchang structure contains 53 percent of the petroleum reserves in the Jiangnan Basin's Qianjiang depression. The Laojunmiao--Shiyougou anticlinal zone contains 90 percent of the oil reserves in the Jiuquan Basin.

Unconformity surfaces, rifts and reservoirs were the three oil and gas migration routes in continental sedimentary basins. The geologic conditions of each basin are different, however, and the pattern of migration depended

on local conditions. Continued subsidence predominated during the genesis and development process in the Songliao Basin, and there was no depositional hiatus. However, large-scale continuous fluvial deltas formed large sandstone bodies which extended directly into the center of the source rock and became a primary oil and gas migration route. After the oil and gas had entered a large sandstone body, hydrodynamic forces and gravitational differentiation caused it to migrate laterally along the sandstone body. All of the basins in western China underwent intense tectonic activity during each of the periods of the Mesozoic and Cenozoic eras. This created large-scale unconformity surfaces between the geological eras. These regional unconformity surfaces formed broad routes for the lateral migration of oil and gas and were a primary route of oil and gas migration. In the Karamai oil pool of the Junggar Basin, the oil and gas that formed during the Permian Era in the oil-generating depressions of Manasi Hu migrated northwest for 80 kilometers along the regional unconformity surface between the Permian and Triassic systems to form the large oil reservoir at Karamay. The oil and gas in the oil pools at Yaerxia, Laojunmiao and Shiyougou in the Jiuquan Basin came from the Lower Cretaceous oil-generating depression at Qingxi in the western part of the basin. It migrated laterally for 10 to 30 kilometers along a regional unconformity surface and accumulated at the Laojunmiao anticlinal zone. The lateral migration of oil and gas for fairly long distances along an unconformity surface was not seriously restricted by oil-generating depressions. Rich accumulations of oil and gas could form outside the scope of source areas if a trap and accumulation body were produced during the oil formation period. For this reason, the regions favorable to oil and gas occurrence are not limited to the interior of the oil-generating depressions (the ancient lake basins). The outer margins of the source depressions are also important zones for oil exploration if there is a structure in combination with favorable facies. The depressions of the northern China basins have the three migration routes of unconformity surfaces, rifts and inside sandstone bodies. These three types of migration routes were often intermixed and formed extremely favorable patterns for the migration of oil and gas. An example is the Yangsanmu oil pool in the Huanghua Depression. After coming from an old destroyed Lower Tertiary oil pool at Wangxuzhuang in the eastern part of the depression, the oil and gas migrated vertically along the main fault of the South Dagang Rift to an unconformity surface between the Guantao and Dongying sediment groups and then migrated laterally for 15 kilometers along the unconformity surface. When it reached Yangsanmu, it once again migrated vertically along the Yangsanmu Rift, accumulated in Upper Tertiary sandstone strata and formed a secondary oil pool.

The long-term migration of oil and gas is a special characteristic of the Mesozoic-Cenozoic continental sedimentation basins in China. This has been confirmed by geochemical indicators. The era of oil and gas migration in the compression basins in the western part of China could extend through two geological periods. An example is the Jiuquan Basin. The migration of the oil and gas in the Lower Cretaceous source beds at Xinminbaoqun began at the end of the Cretaceous and ended in the Upper Tertiary. In the Triassic source beds of the Ordos Basin, the oil and gas began to migrate at the end of the Upper Triassic. After the Yan'an system sediments of the Jurassic, it went along an unconformity surface and continued to migrate toward and

accumulate in the Yan'an sandstone. This continued through the Upper Jurassic and formed large structural oil pools. This long-term migration of oil and gas shows that there are vast prospects for oil in the continental basins. In the basins of western China, for example, oil formed during the Cretaceous period may be found in Tertiary red beds. The red beds that are widely distributed throughout the northern China basins do not contain merely secondary oil pools from secondary migrations. Large amounts of oil pools from primary migrations out of Lower Tertiary source rocks also may be found there.

Vertical migration and multi-period accumulation and dispersion were the primary patterns of oil and gas migration in the faults of northern China. Three points show that the long periods of faulting led to the vertical migration of oil and gas:

1. The crude oil is heavier on top than on the bottom, while the natural gas is lighter on the top than on the bottom, and there are obviously high abnormalities in the total degree of mineralization of the water of the strata. There is a regular increase in the specific gravity and the viscosity of the crude oil of the North Dagang oil pool in the North China Basin moving from the Sha 3 member of the Lower Tertiary to the Ming 2 member of the Upper Tertiary. The specific gravity increases from 0.828 to 0.9322 and the viscosity increases from 2.87 centipoise to 112.6 centipoise. The heavy hydrocarbon content of the natural gas decreases from 23.2 to 2.1 percent going downward, while the degree of mineralization of the oil field brine falls from 15,900 ppm to 3,358 ppm.
2. The height of fault displacement controls the height of gas and oil migration. The result is the formation of secondary oil and gas pools in shallow non-source strata (Table 3).
3. There are rich accumulations of oil and gas on the two flanks of a main fault. Going from bottom to top, six oil-bearing strata systems were encountered during drilling in the rich accumulation region near the main fault at Gangdong in the Dagang oil field of the North China Basin: the Sha 3 member, the Sha 2 member, the Lower Sha 1 member, the Dongying group, the Guantao group and the Huazhen group. The total thickness of the oil and gas horizon is 196 meters. The length of the oil-bearing drilling segment in the rich accumulation area in the Shengtuo oil field was 1,500 to 2,000 meters. In the four petroliferous strata systems of the Sha 2 member, the Dongying group, the Guantao group and the Minghua group, there more than 77 oil layers and the thickness is greater than 245 meters. The many eras of fault activity created multiple periods of oil and gas accumulation and dispersion. There were three primary periods of oil and gas migration and accumulation:

The early period (the early part of the Oligocene in the Lower Tertiary). The source beds had just developed and the oil and gas was mainly restricted to generation and reservoiring in rocks of the same age. It formed sand lens oil pools, unconformity oil pools and ancient sunken mountain oil pools. The crude oil is distinctly primary. These were hidden oil and gas reservoirs.

Table 3. Data on the Relationship Between the Height of Fault Displacement and the Vertical Distribution of Oil and Gas in the Depression Faults of Each of the North China Basins

<u>Name of Depression</u>	<u>Oil Field</u>	<u>Primary Oil-Bearing Layer</u>	<u>Name of Fault</u>	<u>Height of Fault Displacement (meters)</u>	<u>Height of Oil and Gas Migration (meters)</u>
Huanghua depression	Gangxi oil field	Upper Tertiary	Gangxi main fault	350	400
	Gangdong oil field	Upper Tertiary	Gangdong main fault	600	950
	Yangsanmu oil field	Upper Tertiary	Yangsanmu main fault	900	1050
	Kongdian oil field	Upper Tertiary	Kongdong main fault	1000	1100
Jiyang depression	Shengtuo oil field	Upper Tertiary	Zhoubu main fault	800	900
	Gudao oil field	Upper Tertiary	Gubei main fault	670	700
Liaohede depression	Dapingfang oil field	Upper Tertiary	--	500	530
Bozhong depression	Chengbei oil pool	Upper Tertiary	Chengbei main fault	900	1000

The middle period (the end of the Oligocene in the Lower Tertiary). The source beds attained a certain degree of maturity and the oil and gas began to migrate on a large scale. This was also a main period of oil formation. Large structures and fractures were formed during the later part of the Oligocene. This was favorable to the migration and accumulation of oil and gas. Lateral migration predominated during this period, with associated vertical migration. The main oil and gas pools in the North China Basin were formed during this period.

The later period (the Upper Tertiary). This was the era of the finalization of oil and gas migration. Tectonic movements and fracturing activity during the Upper Tertiary destroyed some of the ancient oil pools and caused the oil and gas to be redistributed. The migration of oil and gas during this period was primarily in a vertical direction and formed large numbers of secondary oil pools. The secondary oil pools of the Upper Tertiary and the rich accumulation zones on the flanks of main faults were formed during this era.

In summary, there was a great deal of regularity in the distribution of oil and gas migration characteristics and patterns and in the oil and gas in the source depressions in the continental basins. The oil and gas pools lie in a circular distribution around the source depressions, and the quality of the crude oil becomes heavier moving outward from the depressions toward their rims. The source beds on top of the second era zone are larger at the bottom and smaller at the top, forming a pagoda-like shape. In summary, the result of the oil and gas migration was that broad distributions of oil and gas were formed in the entire source depression. For this reason, whenever a source depression is found, then a region of rich accumulation of oil and gas has also been located.

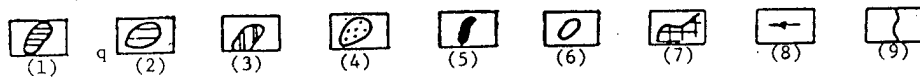
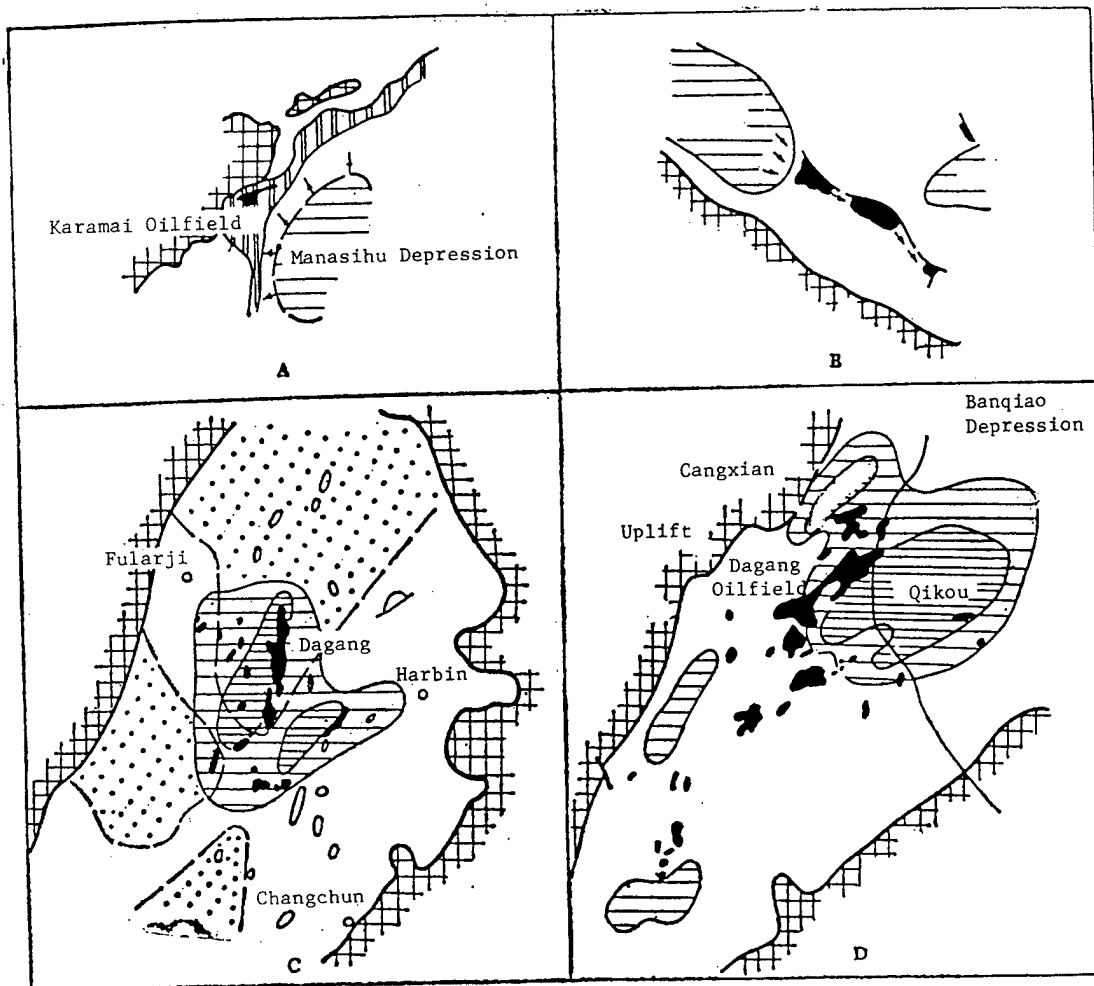
### III. Patterns of Oil and Gas Accumulation and the Conditions for the Formation of Large Oil Fields in the Continental Basins

There are many types of oil and gas pools in the continental basins of China. They may be divided into three major groups based on the above analysis.

Type 1: Structural oil pools. These include anticlinal oil pools, draped anticline oil pools, compression anticline oil pools, rift anticline oil pools, inverse traction anticline oil pools, salt dome anticline oil pools and fault-block oil pools.

Type 2: Compound oil pools. This type includes ancient buried hill pools, strata upper incline thinout oil pools, overlapped unconformity oil pools and hydrodynamic oil pools.

Type 3: Stratigraphic lithic oil pools. This type includes alluvial sand bodies, river channel sand bodies, low permeability sandstone traps, dense oil traps and other lithic oil pools.



Key:

- A. Junggar Basin
- B. Jiuquan Basin
- C. Songliao Basin
- D. Huanghua Depression

- 1. Oil generation center
- 2. Oil-generating depression
- 3. Favorable zones for oil and gas accumulation
- 4. Lithic region of oil accumulation
- 5. Oil field
- 6. Structure
- 7. Basin boundary
- 8. Direction of oil and gas migration
- 9. Sea-land interface

These different types of oil and gas pools are organized into oil and gas accumulation zones and form large continental oil fields. There are four major types in the different types of main bodies in the basins:

1. Multiple zones of oil and gas accumulation. The Renqiu, Shengli, Dagang, Liaohe and other such oil fields in the fault basins of northern China are of this type. The most prominent characteristic of oil fields with multiple accumulation zones is that the different types of oil and gas reservoirs are spread out in an orderly and regular distribution on top of a second era structural zone, forming a complex oil and gas reservoir body. They are characterized by multiple strata systems and multiple oil pools stacked in successive layers, and the entire zone contains oil.

Sunken mountain hidden oil pools and sunken mountain weathered body oil pools developed at the bottom of the multiple oil and gas accumulation zones. Unconformity oil pools and stratigraphic overlap oil pools developed above and below the unconformity surfaces. Rift anticline oil pools or fault-block oil pools developed at the center of the accumulation zones. Conglomerate cone oil pools and rolling anticline oil pools developed on the fault terraces of the steep flanks. Stratigraphic upper incline thinout and biogenic beach (or oolitic beach) oil pools and alluvial sand lens-shaped body oil pools developed on the gentle flanks or peripheral slopes. Shallow strata secondary oil pools or gas pools formed at the apex of the main faults. There are differences in the organizational patterns of the oil and gas pools in the multiple oil and gas accumulation zones because of differences in the structural position, background of geological development and conditions of formation of the basins in which they are located. Some have ancient sunken mountain oil pools as the main body, some have rift anticlines and fault-block oil pools as the main body. Some have rolling anticlines as the main body, while others have Upper Tertiary secondary oil pools as the main body. The Renqiu oil field in the North China Basin is a large-scale multiple oil and gas accumulation zone which has ancient sunken mountains as the main body. The oil field is located in the central part of a subsidence on the flank, and the source depression covers an area of 7,700 square kilometers. The source rock is as much as 1,000 meters thick and is rich in oil. The reservoir beds are siliceous dolomite from the Sinian period. Cracks and holes developed, and the permeability is good (the effective permeability is 0.4 to 3 Darcys). These are excellent conditions for oil storage. The ancient sunken mountains developed over a large area and to a high degree for a long period, and provided an enormous space for oil and gas accumulation. There is a basement fault on the western side of the ancient sunken mountains which underwent long-term movement. This caused the Lower Tertiary source beds to come into contact with the accumulation bodies. On the eastern side of the ancient sunken mountains, an unconformity came into contact with the Lower Tertiary source beds and created favorable conditions and excellent migration routes for "oil to be generated in young source beds but reser-voired in old rocks." The zones of crack and hole development in the carbonatite within the ancient sunken mountain traps control the rich accumulations and high yields of oil and gas. The daily output of the oil wells is over 1,000 tons per day. The North Dagang oil field is a large-scale multiple oil and gas accumulation zone with a rift anticline as the

main body. The oil field is located between the Qikou and Banqiao source depressions. The source rock is as much as 2,000 meters thick and has the conditions for supplementation by rich oil sources. A succession of fan delta sandstone bodies developed in the northern part of the depression, forming an excellent reservoir bed and a generation and reservoir capping combination. The anticlinal zone developed over a long period on a large scale and provided an enormous setting for oil accumulation. The confining fault blocks, countertraction and draped anticlines and other traps on either side of the main rift provided the conditions for rich accumulations and high yields of oil and gas. The formational conditions of the Shengli and Hexi Slope oil fields are similar to those of the North Dagang oil field, except for the main body oil pools. The Shengli oil field has a rolling anticline oil pool as the main body, while the Hexi oil field has a stratigraphic oil pool as the main body. The Gudao oil pool is a large-scale secondary anticlinal oil pool. A large-scale Upper Tertiary draped structure is located on top of a convex rise. The lack of a Lower Tertiary source bed caused the Upper Tertiary to come into direct contact with Ordovician limestone facies. The Upper Tertiary had an excellent system of large sandstone and conglomerate accumulation beds that are covered by 500 to 1,000 meters of mudstone. At the large rift, the convex rise comes into contact with source depressions on either side. This forms an excellent route for vertical migration. The Lower Tertiary sources migrated vertically and were redistributed, accumulating in a Lower Tertiary shallow anticlinal structure and forming a large secondary oil pool. The geological characteristics of these multiple oil and gas accumulation zones in the North China Basin are extremely complex, and are expressed as multiple fault blocks, multiple oil and gas beds, multiple pressure systems, multiple fluid qualities and multiple sources of motive energy. This makes exploration and development very complex.

2. Changyuan-type oil and gas accumulation zones. The Daqing oil field in the Songliao Basin is representative of this type. The oil reservoiring characteristics of this type of oil and gas accumulation zone are relatively simple. The structural morphology, oil pool types, fluid qualities, pressure systems, and oil and water boundaries are basically the same for each of the oil-bearing stratigraphic systems. There are, however, substantial vertical and horizontal differences in the conditions and qualities in the distribution of the source beds. Shallow gas pools often occur at the apex of Changyuan-type oil pools. The Daqing oil field is 120 kilometers long from south to north and 15 miles wide from east to west, covering a total area of more than 2,000 square kilometers. It is located in a subsidence in the center of the Songliao Basin and has a Lower Cretaceous system of oil-bearing strata with source beds 800 meters thick and rich oil sources. The tongue-shaped penetration from north to south of the large sandstone bodies coming from the plains deltas at the northern rim of the basin into the source depressions creates an ideal combination of generation, storage and covering. The many high points formed the Daqing and Changyuan structures and enormous trap spaces. The large sandstone bodies, large traps and deep source depressions that were combined into one body and the contemporaneous periods of structural development and oil formation provided excellent conditions for the rich accumulation of oil and gas. Deltaic tributary channel facies and river-mouth sandbar facies are areas of rich, high-yield oil and gas.

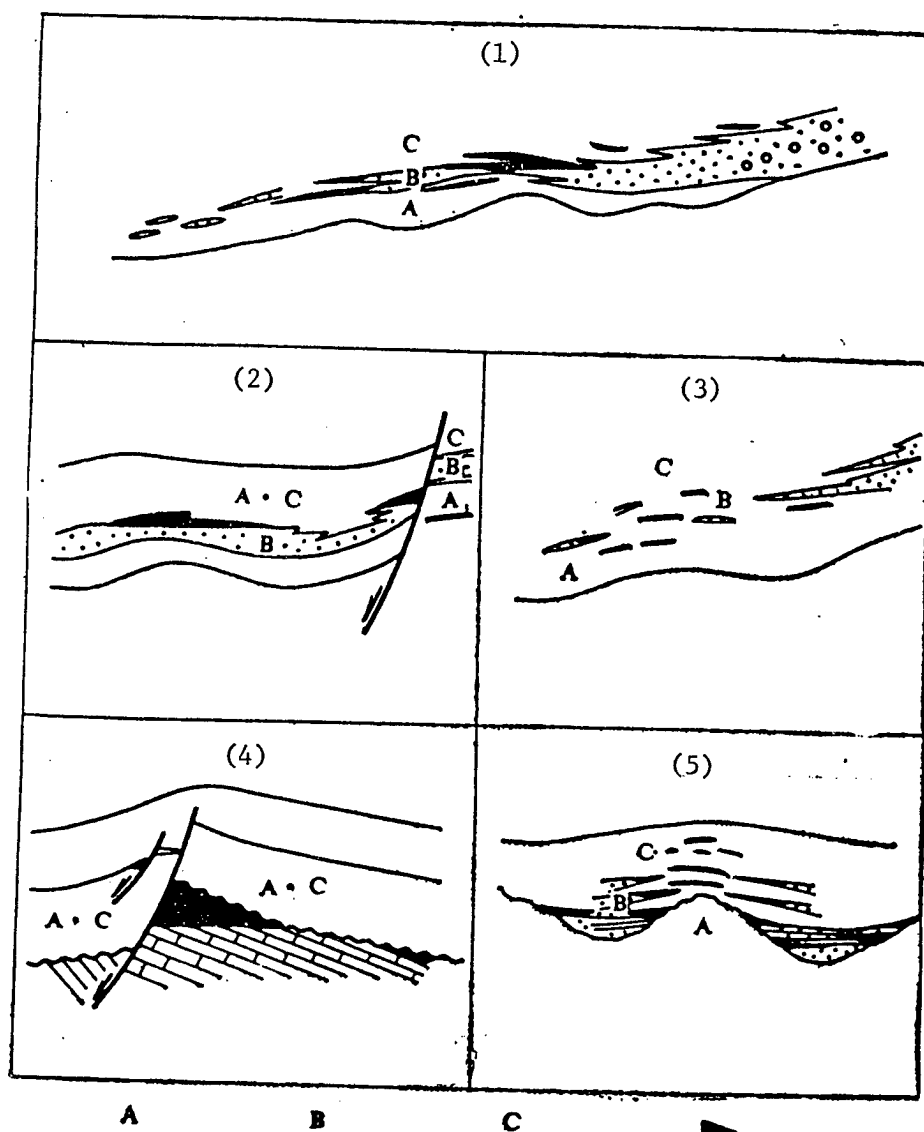
3. Large-scale structural lithic oil and gas accumulation zones. Large numbers of oil and gas accumulation zones of this type developed on the gentle slopes of the Ordos Basin. The ancient land features at the peak of the Triassic system controlled the formation of oil pools. The special characteristics are that oil-bearing zones were formed by large numbers (several dozen to several hundred) of single oil pools in successive continuous layers. The differences in the degree of development of the single oil pools causes major differences in the degree of successive layering. The oil pools are primarily structural oil pools and lithic oil pools that are divided into three zones from bottom to top. The trough bottom contains mainly oil pools sheltered by erosional surfaces, while the two sides of the trough are primarily upper incline thinout oil pools. The high parts of the second-era structural zone are primarily banded, braided and convex lens oil pools. This forms a pagoda-shaped distribution. The Maling oil pool in the Ordos Basin is a large structural lithic oil and gas accumulation zone. This oil pool is located on the eastern slope of a source depression, and the oil-bearing strata are from the Lower Jurassic system. The Upper Triassic source beds are 300 to 500 meters thick and the scope of oil generation covers 54,000 square kilometers, providing a rich oil source. The dissected depth of the ancient erosional surface at the peak of the Upper Triassic reaches 200 to 300 meters, which caused the source beds to come into contact with the Jurassic reservoirs. The large gentle nose-shaped structural zones on the slope provided excellent conditions for oil and gas accumulation. The fluvial facies sediments in the troughs of the ancient erosional surface are a favorable facies zone. Upper incline thinout sandstone sheltered by an ancient erosional surface and by compacted sandstone is a primary oil-bearing formation. The upraked area of the nose-shaped structures and the two sides of an "erosional trough" are regions of rich, high-yield oil and gas accumulation.

4. Compression anticline oil and gas accumulation zones. Compression anticline oil and gas accumulation zones are common throughout the compression basins of the southwest. The oil pools are strictly controlled by the anticlinal zones, and are expressed as long, linear oil pool formations. This type includes the Laojunmiao oil field in the Jiuquan Basin, the Yixikelike oil field in the Junggar Basin and other oil fields. They are 10 kilometers long but less than 300 meters wide.

There is regularity in the distribution of zones of oil and gas accumulation in each of the basins. This shows that the distribution and location of each type of oil and gas accumulation zone can be predicted if the type of basin is known. The concept of multiple zones of oil and gas accumulation is of great importance for guiding exploration. The principle that should be used to guide exploration in multiple zones of oil and gas accumulation is that it must be based on dissection of the entire second zone and should adopt the principles of giving consideration to both deep and shallow areas, multilayer exploration and multi-type exploration. It is especially important that the first well in ancient sunken mountain multiple zones of oil and gas accumulation must be drilled down to bedrock.

The formational conditions of oil and gas pools in the continental basins may be grouped into three major categories of oil formation. Category 1 is oil that is generated and reservoired in rocks of the same age. The development of enormous deltaic sandstone bodies which come in from a lake basin rim and penetrate into deep lacustrine facies source rock was common in the deep oil-generating depressions. These led to one of the most favorable conditions for the formation of oil. The Daqing and Shengli oil fields are both of this type. There are enormous source beds which overlie the reservoir beds within the oil-generating depressions. There are, therefore, source beds as well as capping strata, which formed oil fields under the conditions of long-term paleostructural development. An example is the Fuyu oil field in the Songliao Basin. Moreover, the turbid sand bodies and river channel sand lenses in the source depressions also commonly formed oil and gas pools which were generated and reservoired in rocks of the same age. In summary, the generation and reservoiring of oil and gas in rocks of the same age is a primary form of oil formation in the continental basins, and constitutes over 80 percent of the total reserves in the basins. Type 2 is oil that is generated in young source beds but reservoired in old rocks. The tectonic movements that occurred prior to the enormous source bed deposits formed an ancient concavo-convex terrain on the lake bottom (ancient sunken mountains) that was covered in a later period by oil-generating rock bodies. The ancient sunken mountains became excellent reservoirs and formed the unusual pattern of oil that is generated in young source beds but reservoired in old rocks. Oil pools can form if this type of oil formation pattern is higher than the ancient sunken mountains at the lower boundary of the source bed deposits. This type includes the Renqiu and other oil fields in the North China Basin, and the Yaerxia and other oil fields in the Jiuquan Basin. This type constitutes about 8 percent of the total reserves in continental basins. Type 3 is oil that is generated in old source beds but reservoired in new rocks. Denudation of the sedimentary hiatus caused the new sedimentary accumulation beds on top of the erosional surface to directly cover the source beds under the erosional surface. The oil source came from the source rock under the unconformity surface, forming the pattern of oil that is generated in old source beds but reservoired in new rocks. The Jurassic oil pools in the Ordos Basin are the most typical of this type. In addition, the basins of the southwest often have oil that was generated in lower strata which migrated along an unconformity surface or fault and accumulated in upper strata. They are also of this type. This type constitutes 12 percent of the total reserves in continental basins. Although the large continental oil fields formed different types of geological settings and there are differences in geological conditions and oil formation combinations, there are five geological elements which are necessary for the formation of large continental oil fields.

1. A deep oil generating depression. A large amount of practice in exploration has proven that all of the continental oil fields are located within or on the periphery of deep oil generating depressions. These large oil fields are controlled by the main period of subsidence and the main generation and reservoiring capping combination. Examples are the Daqing and Fuyu oil fields in the Songliao Basin, which were related to the main subsidence



Key:

1. Oil generated and reservoired in rocks of the same age (intrusion type)
  2. Oil generated and reservoired in rocks of the same age (overlying type)
  3. Oil generated and reservoired in rocks of the same age (convex lens type)
  4. Oil generated in young rocks and reservoired in old rocks (sunken mountain type)
  5. Oil generated in old rocks and reservoired in young rocks (trough type)
- A. Oil generating strata  
B. Accumulation strata  
C. Capping strata

period of the Qingshankou group in the Cretaceous. The formation of the large Shengli, North Dagang, Shuguang-Shuangxiling, Renqiu and other oil fields in the North China Basin are related to the main subsidence period in the Sha 3 member of the Lower Tertiary. This was determined by the proximity to sources, sufficient sources and short-distance lateral migration in the basins. Thus, if we wish to locate large continental oil fields, we must first of all determine the location and period of formation of deep depressions. Whenever a deep source depression is found, then a clue to the location of a large oil field has also been found.

2. A large structural trap. The most effective and best large trap in the deep depressions is a trap which was formed earlier than or at the same time as the oil generation period, which must also be accompanied by an excellent generation and reservoiring combination. All of the large oil fields in China are of this type (e.g., Daqing, Fuyu, Shengli, etc.).

Some large-scale structural traps missed the opportunity to bear oil because they lacked a good generation and reservoir capping combination or because the period of structural formation came later. Examples include several large structural traps in the northern and eastern parts of the Songliao Basin. They never formed oil pools because they lacked a good generation and reservoir capping combination. Although some structures in the deep depressions have excellent generation and reservoir capping combinations, they never formed oil pools because the structures were formed after the oil accumulation period.

There are many types of large traps in the continental basins, including anticlinal traps, stratigraphic traps, ancient sunken mountain traps, and so on. This is especially true of large compound traps. They were formed by a succession of structural, stratigraphic, overlapping, lithic and other elements. They are not very visible on structural maps and are of the hidden type. They become obvious only after analysis of a great deal of exploratory drilling practice. Many of the traps in the North China Basin have this type of condition. Examples include the West Slope oil field at Liaohe, the Maling and Wuqi oil fields in the Ordos Basin, and others.

3. A large sand body (or other large reservoir body). A large sand body which penetrates deep into the interior of a lake basin is an important condition for the rich accumulation of oil and gas, and all of the rich accumulations of oil and gas are associated with large sand bodies. Within the large basins, we should look closely along the direction of the major axis for distant source large plains and deltaic sand bodies that were created by the multi-period advance and retreat of water and which extended into a deep lake. We must pay very close attention to this in fault basins. The near-source fan delta sand bodies that formed in the transitional zone from the slopes to the depression enter the source depression in a tongue-shaped or fan-shaped form, and form an excellent generation and reservoir capping combination. The gradual transformation from delta leading edges to deep lake facies deposits have excellent oil source conditions as well as superior oil and gas migration and accumulation conditions.

4. An unconformity (or sedimentary hiatus). An unconformity surface above and below the main source rock system in a source depression is an important condition for a large oil field with rich accumulations. Many of the large continental oil fields in China are closely associated with an unconformity surface. The horizon with the richest reserves of oil and gas in the North China Basin is the unconformity surface between the Upper and Lower Tertiary systems, the unconformity surface at the bottom of the Lower Tertiary system, and above and below the second sedimentary hiatus within the Lower Tertiary (i.e., between the Sha 4 and Sha 3 members, and between the Sha 3 and Sha 2 members). The formation of large oil fields above and below an unconformity provides three beneficial conditions: 1) there are many types of entrapment conditions above and below the unconformity surface which are favorable for the formation of oil pools (e.g., overlapping, unconformity, ancient landform and ancient sunken mountain traps, lithic and structural traps, etc.). 2) a sedimentary cycle often began above an unconformity surface and deposited a group of loose sandy conglomerate strata, which formed an excellent reservoir. 3) unconformity surfaces are an important oil and gas migration route in the continental basins. The migration occurs on a fairly wide scale and is highly favorable for the formation of an oil pool. Thus, intensive research on the depositional hiatus above and below source rock systems is of great importance in the search for large oil fields in the continental basins and should be given especially close attention.

5. A large contemporaneous fault. The relationship between the formation of large oil and gas fields and large contemporaneous faults is especially close in the fault basins. Contemporaneous faults in the source depression are oil and gas migration routes and can form primary oil pools. The oil and gas also can continue along the faults and form large secondary oil pools above. Contemporaneous faults in the fault basins often occur in the transitional zone between the slopes and the depression, creating contemporaneous faults and associated rolling anticlines due to gravity slippage. Sandstone develops very well in the descending pan of the faults and forms small-area oil and gas fields with rich accumulations.

The first three of the above five conditions are the basic conditions, while the last two are supplementary conditions.

## Conclusion

In summary, there are definite regularities in the formation of oil in the continental basins. There are four general basic laws:

1. The source depression controls the distribution of oil and gas fields. The deep troughs of continued subsidence over long periods are the centers of oil generation, and are zones of rich oil and gas accumulations. "Delineating the depressions" is the primary task in the search for continental oil fields.

2. Ancient lakes control the formation of oil and gas, and the most favorable regions for continental oil formation are near the strand lines of ancient lakes, where large oil fields can be found. "Demarcating the strand lines of ancient lakes" is also among the main tasks in the exploration for oil and gas in continental basins.

3. Large structural zones in combination with favorable facies zones in the source depressions form favorable zones for oil and gas accumulation. The different types of basins have different types of oil and gas accumulation zones, and "demarcating the zones" in the depressions (demarcation of large structural zones) is also important work in the search for oil in continental basins.

4. Multiple zones of oil and gas accumulation are common patterns of accumulation in the continental basins. Under different geological backgrounds, the multiple zones of oil and gas accumulation have different main oil accumulation bodies and reservoiring sequence. For this reason, the primary type of reservoir must be determined according to the geological background conditions and oil formation combination of the basins.

In summary, "delineating the depressions," "demarcating the strand lines," "demarcating structural zones" and "determining types" (determining types of oil reservoirs) are of tremendous importance in the theory and practice related to continental oil formation for guiding gas and oil exploration in continental basins.

#### FOOTNOTES

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DEPOSITIONAL FEATURES AND OIL AND GAS DISTRIBUTION IN SOME FAULT-DEPRESSION  
LAKE BASINS IN NORTH CHINA

Beijing SHIYOU XUEBAO [ACTA PETROLEI SINICA] in Chinese Vol 4, No 3, Jul 83  
pp 13-21

[Article by Wang Defa [3769 1795 4099], Sun Yongchuan [1327 3057 0278] and  
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College]

[Text] Abstract

This article briefly discusses the distributional characteristics of Tertiary oil and gas in the eastern part of China and their relationship to Tertiary sedimentation.<sup>1</sup> It points out that Tertiary sedimentation was controlled by influences from the character, developmental history and structure of the basins, as well as by faulting activity. Proximity to source area, a short sediment transport distance and the turbidity current hydrodynamics of floods are among the salient features. Local areas developed lagoonal biogenic reefs and clastic limestone deposits. A brief description of Tertiary petroliferous sand bodies already established through exploration is provided. The types of sand bodies include: submarine alluvial fans (also called offshore submarine fans), near-source deltas, turbidity current channel sands, submarine sheet-flow sands (laminar flow), fluvial sand, lake shelf sand, reef limestone--clastic limestone bodies and other small littoral sand bars. In the last part of the paper, the guidelines for oil exploration in Tertiary rocks in the basins are discussed from the perspective of sedimentation.

Preface

Research on the sedimentary facies and sedimentary environments of the Tertiary petroliferous basins in the eastern China region that has been carried out for more than a decade provides us with a certain understanding of the relationship between Tertiary oil and gas occurrence and sedimentation. This has deepened our understanding of the temporal and spatial regularities in

oil and gas distribution and has bolstered our confidence in being able to locate new oil and gas resources in the eastern region.

## I. Tertiary Oil and Gas Occurrence and Sedimentation

Rich Tertiary oil and gas deposits have already been found in the eastern China area in the Bohai Gulf Basin, the Nanyang Basin and other locations. There is a close relationship between oil and gas occurrence and Tertiary sedimentation. The relationship includes the following points:

1. Within a single basin or depression, the most abundant occurrence of oil and gas is on the slope of a deep depression that is adjacent to a source area. The least amount is found in gentle platform regions which are distant from or lack source areas. It can be seen that the degree of richness in oil and gas is always related to the amount of sediment accumulation. There was intense faulting activity in the Tertiary lake basin or depressions. The boundary of the basin is controlled by faults which create major differences in terrain which is strongly segmented by rises and depressions. The parent rock region of the source area is in the surrounding mountainous area and there is a short sediment transport distance. There are no broad fluvial or alluvial plains between the parent rock region and the basin's waters. The rudaceous rock sediments flowing out of the mountain passes entered the water without undergoing long distance sorting. The degree of maturity of the minerals in the sediments and the degree of maturity of particle structure are both relatively low. The arenite contains 30 to 60 percent detritus and may contain muddy conglomeratic or carbonatite detritus, or other material as well. Particle sorting and psephicity are both poor, and some have assumed a mixed structure. There is a discontinuous facies sequence on the plane. For example, there are fluvial facies in the middle where an alluvial fan entered the lake. The distribution and scope of sand bodies within a basin or depression is directly related to the direction and amount of supply of the source area. Most of the large sand bodies occur on the steep slope of a deep depression in the direction of the supply of parent rock, and therefore have rich accumulations of oil and gas. After a certain transport distance inside the depressions, it grades out from sand to silt, and there has been wave retransformation. The sand bodies become smaller, however, and the scope of oil and gas accumulation also decreases.

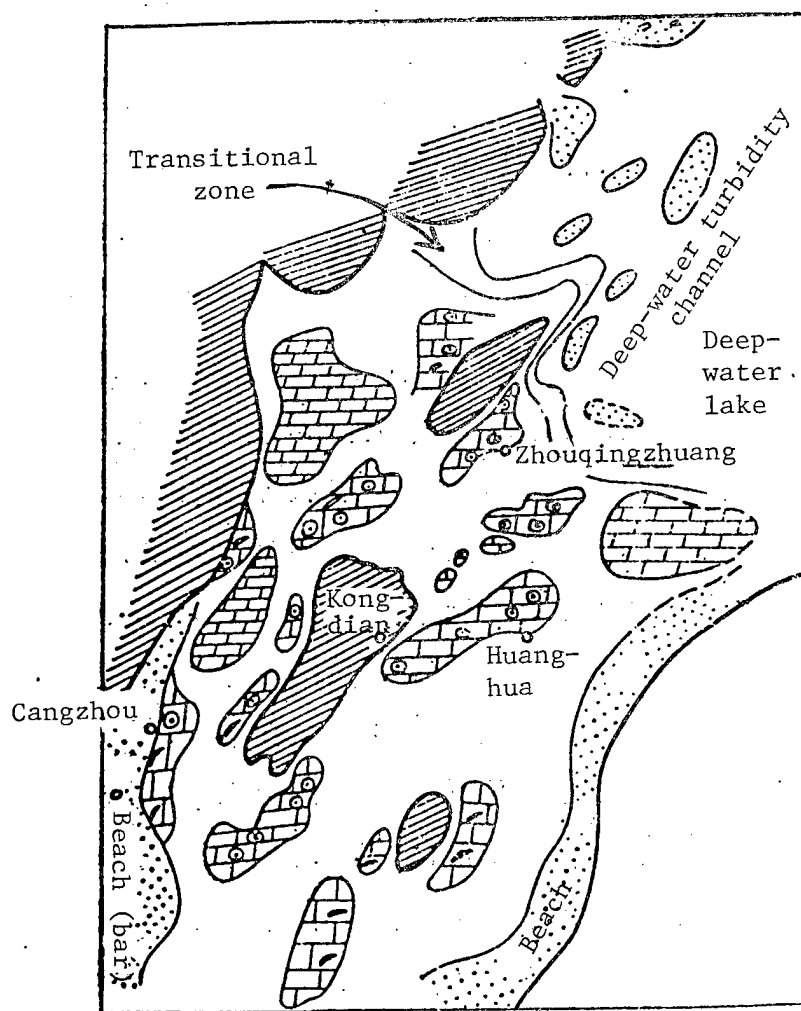
2. There are major differences in the landforms of the basins, and they are strongly segmented and lack gentle rims. For this reason, hydrodynamic forces show clearly that fluvial forces must have been greater than lacustrine forces, with strong unilinear flows and weaker wave transformation in the lakes. Large amounts of silt were carried in by floodwater, with a high density ( $1.01\pm$ ) and swift currents. It entered the lakes directly and formed density currents. Submarine alluvial fans (also called offshore submarine fans) built up in the offshore depressions. These extended into the deep water area within the lake and built up gravity flow channel sands or slipping turbid fans. Submarine sheet-flow lake shelf sands formed on the basin slopes under conditions of shallow swift currents. The obvious fluvial forces during smooth water periods are shown clearly in the profile of alternating turbidity current sedimentary sand bodies and fluvial sand bodies.

The traction-flow-like structures that appear in the turbidity current sedimentation sequence are still the result of an interchange of current forces. Offshore arenaceous sedimentary systems generally did not develop in the basins and they lack broad, smooth alluvial plains. This is due to the limitations of the basin boundaries. There are, however, beach and bar sand bodies on the gentle slopes of the ancient island strands. It can be seen from this that the sedimentation systems within the lake mainly assume three forms: alluvial fans with turbidity current sediment systems, alluvial fans with submarine sheet-flow lake shelf sand sedimentation systems, and submarine fans and deltas or fluvial with deltaic sedimentation systems. Fresh water carbonatite systems and offshore sediment systems also developed at particular times or in local areas. The distribution of oil and gas was obviously controlled by the above sedimentation patterns. The already-verified petroliferous sand bodies are mainly: submarine alluvial fan bodies, gravity flow deep water channel sand, near-source deltaic sand bodies, sand flats (lake shelf sands), fluvial sand bodies and others. There are other types, such as reef limestone and oolitic limestone, which also have some rich accumulations of oil and gas.

3. The differences in basin structural development created an asymmetrical structure of single fault depressions in the basins with one steep flank and one gentle flank. This controls the asymmetry in the planar distribution of sedimentation types. Clastic rock sand bodies, mainly turbidity flow sand bodies and deltaic sand bodies are usually found mainly on the steep flank while the gentle flank primarily has carbonatite sediments. If there was a source area, then a small deltaic sand body, beach bar or other body would form. Local areas also may have developed small diluvial turbidity current sands.

The degree of carbonatite development is strongly related to the amount of source material supplied by terrigenous detritus. For example, there are differences in the Sha 4 member from south to north in the Huanghua Depression. Most of the source areas in the central and northern part came from Yan Shan in the north and there are large deposits of huge clastic rock; the source area in the south came from the Paleozoic limestone mountains of the Cangxian and Chengning uplifts, and there are very thin biogenic--oolitic limestone and unusual lithic stages (oil shale, mudstone, dolomites, marlite, etc.) on the gentle flanks and within the depression. In addition, a transitional zone of clastic rock and biogenic--oolitic rock (clastic rock containing biogenic--oolitic rock; limestone containing varying amounts and distributions of terrigenous detritus) developed on the margin north of Nandagang. Differences in the accumulation of oil and gas distributions occur between the south and north. Oil in the north is reservoired in sandstone, and there are large reserves; oil in the south is reservoired in biogenic limestone, and there are small reserves.

4. In the developmental history of the basins, there are special distribution characteristics in sedimentation types moving upward vertically. The early period of basin development (Kongdian--Sha 4 member sedimentation period) was a period of fill, primarily of volcanic rock--piedmont clastic rock, red buildup and lacustrine evaporite buildup. There were major differences in landforms and strong segmentation. The types of sand bodies are



### Sedimentary Environments of the Sha 1 Member in the Huanghua Depression

primarily fluvial and continental alluvial fans, and yangao lacustrine and other rudaceous and muddy yangao sediments interspersed with basalt strata. In a slightly later period, biogenic reefs and clastic limestone developed in the lagoonal depressions. The mid-Tertiary era (the Shahejie member sedimentation period) was a period during which the lake basin was covered with water as well as a period of fault development. There were broad bodies of water and abundant sedimentary source areas. The lake water was deeper, and there primarily were lacustrine sandstone and mudstone, lacustrine carbonatite buildup and turbidite buildup. There are many types of sand bodies for this period. The basic feature of lake basin sediments is a differentiation of sedimentary facies according to differences in basin structure and source areas. The later part of the Tertiary was a period of basin shrinkage. There mainly was a plain sediment buildup with fluvial--deltaic sand bodies predominating.<sup>2</sup> The periods started to shorten in the Dongying member, and the faults became depressions or plains. The generation and accumulation of large amounts of oil and gas was concentrated mainly during the Shahejie sedimentation period during the middle period of basin development, and they are subject to regional distribution limitations during

the early period of basin formation and the stage of basin shrinkage. The temporal distribution of oil and gas is quite uneven.

5. The sedimentary sand bodies in a basin or depression are closely related to the ancient uplifts within the depressions. The sand bodies in the depressions formed primarily at the foot of ancient uplifts or within subsided pan bottom depressions. This is because the sedimentation patterns were controlled by the ancient topography. Practice has proven that the accumulation of oil and gas at the base of ancient uplifts is an important distributional tendency. The ancient uplifts were paragenetic with an eroded unconformity or overlapping unconformity. This type of unconformity is an oil and gas migration passage, and forms a major condition for non-structural entrapment.

6. Apart from widespread development of saline lake sediments during the 4th Stage of the Shahejie member--Kongdian period of the early Tertiary, there are saline lake sediments formed locally in small fault basins. The rudaceous rock that usually developed at the margin of a saline lake basin came from continental alluvial fans which directly entered the small lakes. The degree and scope of gaoyan occurrence is usually related to the amount of terrigenous detritus that entered the lake. The amount of terrigenous detritus usually increased while the scope of the saline lake decreased. Another special characteristic of the interior of the saline lakes is that the particles in rudaceous accumulations are poorly differentiated and poorly sorted, and lack sand-grade lithic zones. The usually lithic distribution within the lakes is a rudaceous zone (conglomeratic, muddy conglomeratic, arenite, etc.) with a siltstone zone on the outer rim, forming a broad sand flat. Lagoonal deposits formed during the later part of the Sha 4 member, and the lake basin was gradually freshened. Large amounts of carbonatite developed and biogenic reefs or carbonic rock bodies created the conditions for barrier bars in some semi-occluded depressions. These sand flats or barrier bars may contain rich accumulations of oil and gas. The saline lakes also are important regions for the formation and accumulation of oil and gas.

## II. Some Sand Body Sedimentation Patterns Related To Oil and Gas Accumulation

Exploration has proven that the following types of sand bodies are related to the accumulation and distribution of oil and gas. Their sedimentary characteristics are:

1. The sand bodies related to turbidity current sedimentation and the sand bodies related to turbidity current forces in the occurrence of oil and gas in each of the eastern basins can be classified into four types:

Type 1: Underwater alluvial fans (also called offshore submarine fans).<sup>3</sup>

This is a sand body of alluvial fan sediments which flowed directly into the lake. The source area of the fault basin was nearby and there are no alluvial plains. Intense flooding caused the alluvial fans to enter the lake directly and carried along a great deal of rudaceous material with a high

density. This formed a transported turbidity current sedimentary body on the lake bottom. This body may be called a submarine alluvial fan or off-shore submarine fan to distinguish it from a regular fan delta. Because of hydrodynamic transformation during the sedimentation process, these diluvial turbidity current sediments could develop a profile of cross-bedded sandstone. The profile is organized into a normal or reverse cycle assemblage of mixed conglomerates, graduated conglomerate, conglomeratic sandstone, block sandstone, cross-bedded sandstone, parallel-bedded sand, and so on. The organization of each layer, however, is normally rhythmic. The sand bodies occur on the steep flank of the fault near the source area, forming a fan-like body on the plane. They can be divided into three subfacies: 1) fan head subfacies, formed of mixed conglomerates, conglomeratic mudstone, graduated conglomerate, etc; 2) mid-fan subfacies, with graduated beds of conglomeratic sandstone, block sandstone, parallel-bedded sandstone and siltstone. There are submarine braided channel sands and interchannel fine grain sediments; 3) fan toe subfacies, formed of wavy cross-bedded and deformation-bedded fine sandstone, siltstone and horizontally-veined pelitic siltstone, mudstone, and so on. The zones in the submarine fan body favorable to the presence of oil are primarily in the transitional zone in the middle or at the toe of the fan. The generation, accumulation and capping configurations are appropriate, and the porosity and permeability of the sandstone are both excellent. A zone favorable to rich accumulations was formed where the wedge-shaped fan body enters the oil generating depression.

#### Type 2: Deep-water turbidity current channel sands

It is possible that this type of sand body is channel sand formed within a submarine alluvial fan by transportation in braided channels which continued into a deep-water area and extended to overlap the fan body along the lake bottom.<sup>4</sup> The sedimentary profile characteristics are deep-water mudstone interbedded with block sandstone. Analysis of the stratigraphic sequence, bedding structures and granularity shows that there is a special characteristic of particle-flow sediments. In the Maxi and Madong regions at Dagang in the north of the Huanghua Depression, oil flow can be obtained as deep as 3,900 to 4,000 meters. This type of block sandstone is well-sorted and has a high yield. Oil and gas accumulations are associated with local wedge-shaped uplifts and their upper-edge thinout.

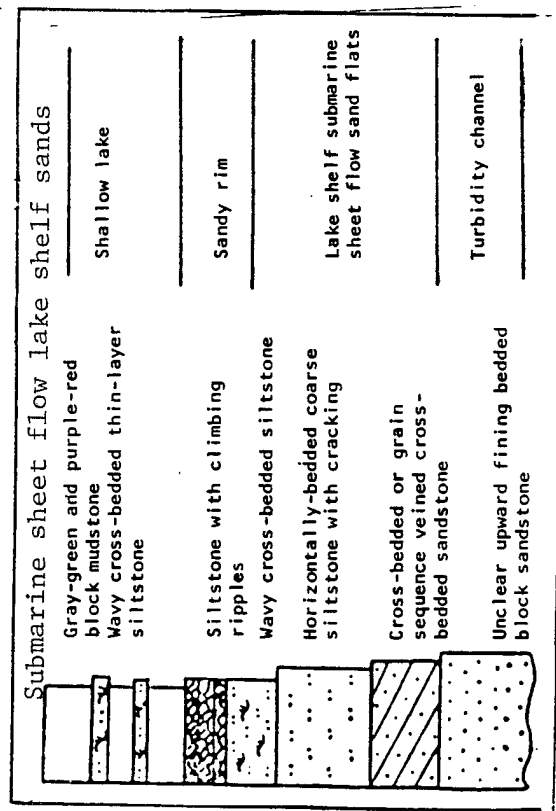
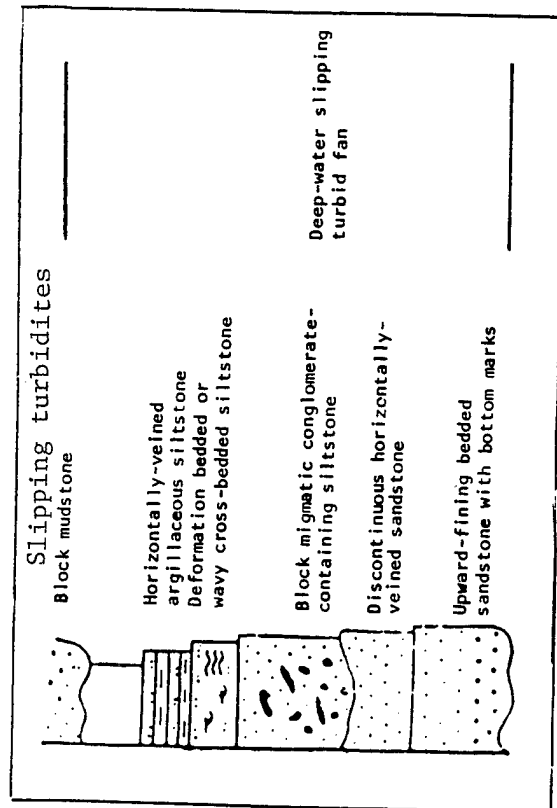
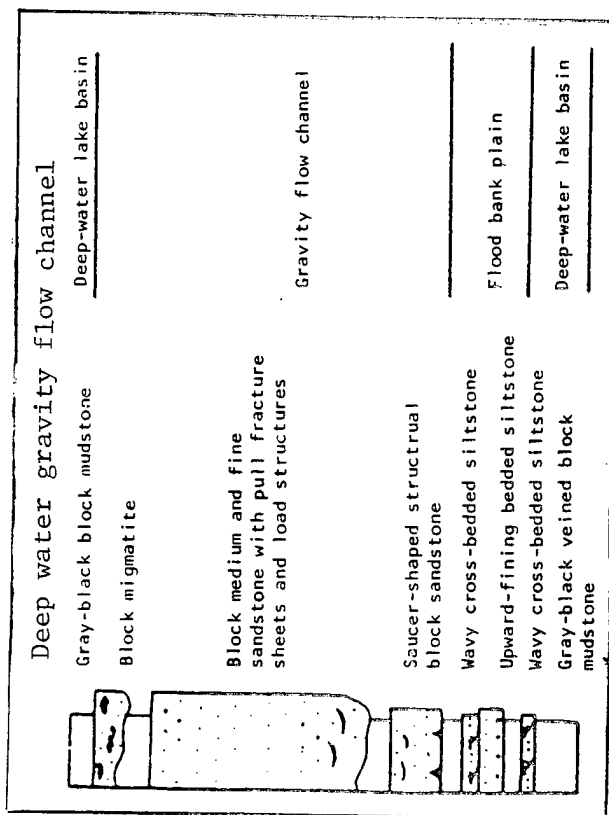
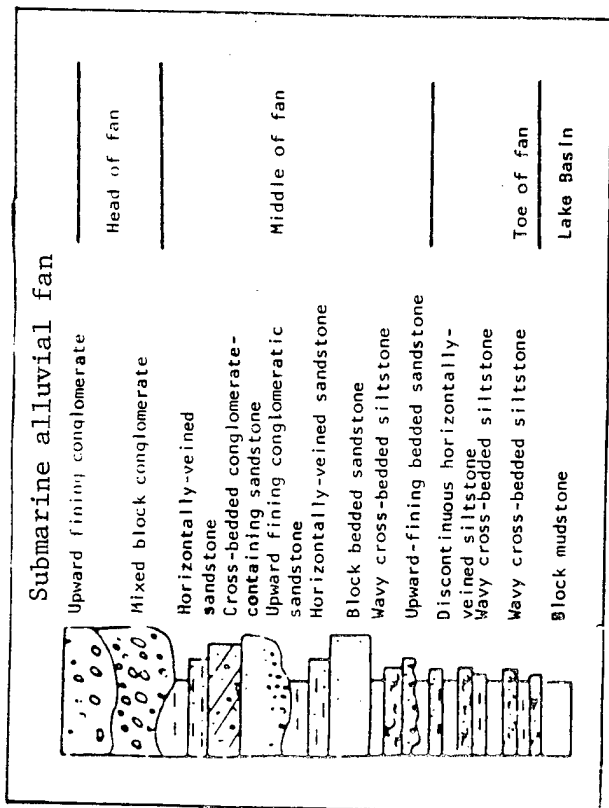
#### Type 3: Deep lake slipping turbidites

These sand bodies are formed primarily of sandstone and there are obvious Bouma sequence stratigraphic sequences and slipping strata with slip folding. They are distributed in the deep depressions and the petroliferous situation in this type of sand body is unclear. It has been inferred that the conditions are not very favorable because of poor structural mixture, porosity and permeability.

#### Type 4: Special highly-fluidic submarine sheet-flow lake shelf sands

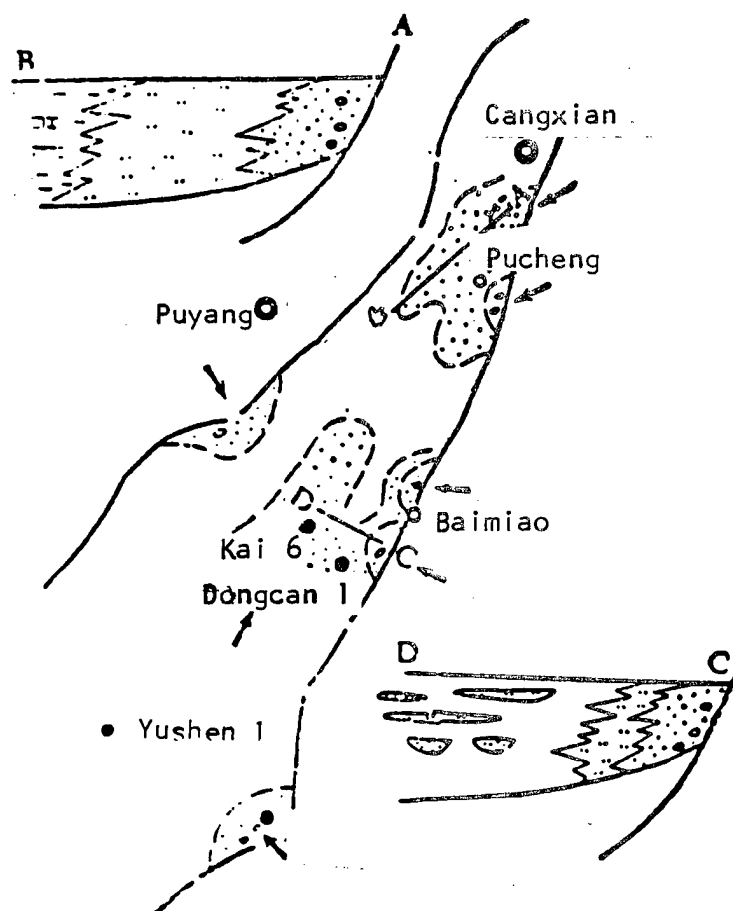
This is a provisional name for sand bodies occurring on the slopes of lake basins or depressions, or within gentle depressions of small basins. There are full supplies of terrigenous detritus and floodwaters carried large

# Sedimentation Patterns of Sand Bodies Associated with Turbidity Flow Deposits



amounts of slit-grade and fine sand detritus in sheet-like submarine sheet-flow transport accumulations. Unstable channels are possible in local areas, but they were not controlled. This type of water current is created underwater with rapid currents and high density in deep or slightly shallower water with turbidity currents and traction-flow transitional conditions. The sedimentary profile is a normal cycle of siltstone and fine sandstone. The stratigraphic sequence from bottom to top is: 1) cross-bedded or parallel-bedded siltstone and fine sandstone with grain sequence vein formations; 2) horizontally-bedded siltstone with development of parting lineation; 3) siltstone and muddy siltstone with wavy cross-bedding and climbing ripples; 4) mudstone and silty mudstone with bioturbation and insect burrows, sometimes with wavy cross-bedding, etc. This type of sand body is relatively-developed within small saline lake basins. In the Dongming depression, they occur from the alluvial fan on the basin rim to the yangao deposits in the basin and form an alluvial fan--yangao lake sedimentation system. Within the basin, the sand bodies extend into the oil-generating depression and can form large oil pools when there is a trap.

Diagram of the Sedimentary Systems in the Dongming Depression



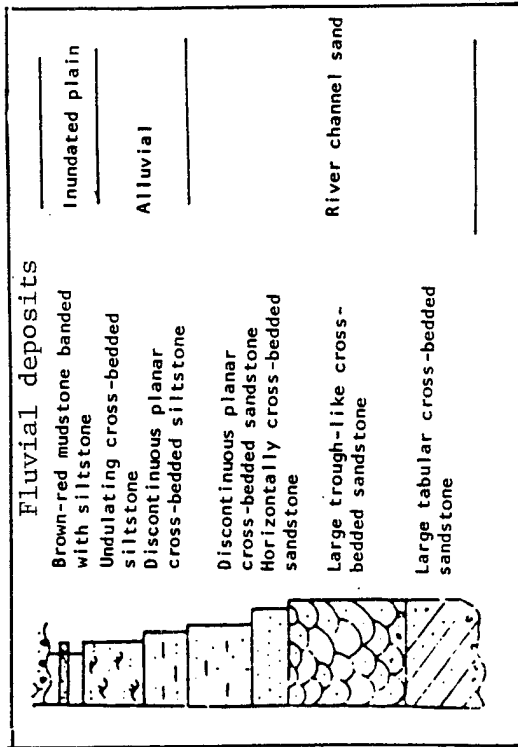
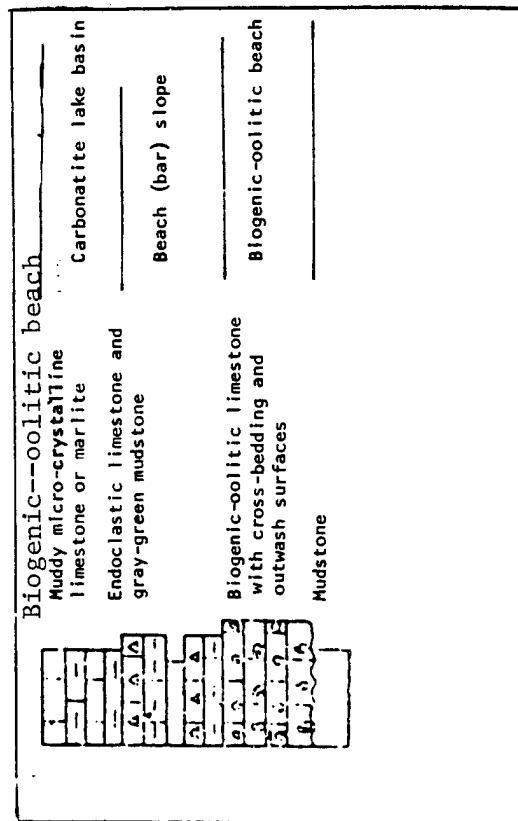
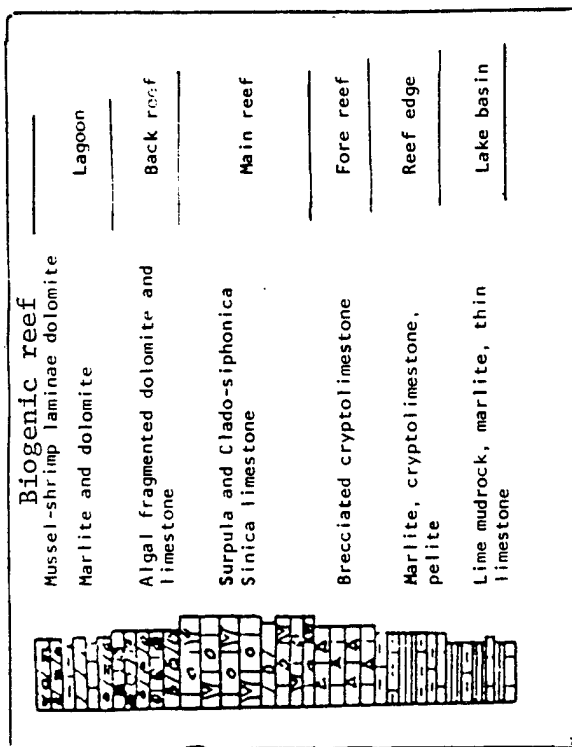
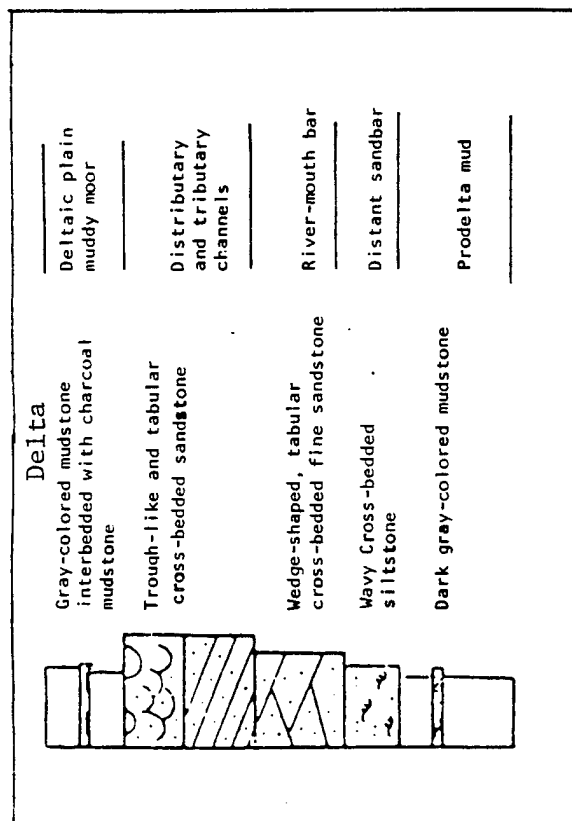
2. Most of the sand bodies and oil-gas occurrences associated with deltas in all of the fault basins in eastern China are near-source deltas, or they may be alluvial fans if they are upstream. They may be medium or small-scale fluvials without a developed alluvial plain, usually smaller-scale delta sand bodies that accumulated near an estuary, usually from 100 to 400 meters thick. The delta sediments were subjected mainly to traction flow and fluvial forces that were greater than lacustrine forces and formed a foreset 3-layer structure with a profile assemblage of a reverse cycle stratigraphic sequence. From top to bottom: 1) prodelta muds--dark colored mudstone and silty mudstone with biogenic fossils; 2) distant sand bars--silt and muddy siltstone with wavy bedding and wavy cross-bedding, and with development of a large number of burrows; 3) estuarine sand bars of medium to fine sandstone, with tabular and sphenoid cross-bedding as well as some planar bedding; 4) deltaic plain facies of distributary channel sands and interchannel mud or charcoal mudstone, and so on. The oil and gas in the delta sand body accumulated mainly in the estuarial bar of a frontal sand bar. The porosity and permeability are excellent and can reach 20-35 percent and 2-10 Darcys. Oil generation, sand bodies and the rolling anticline of contemporaneous fault footwalls and the fault-confinement created favorable conditions for rich accumulations. For this reason, the delta sand bodies in several of the eastern basins have accumulated oil and gas pools to a certain extent.

3. Fresh water carbonatite biogenic reefs and biogenic--oolitic beaches (or bars) and oil- and gas-containing carbonatite developed on the gentle slope platform areas in the basins or depressions. The water here was shallow and covered a large area, with an insufficient supply of terrigenous detritus. This formed biogenic reefs (Sha 4 member) and biogenic and oolitic limestone beaches and bars (Sha 4, 3, 1 members).

Biogenic reefs have previously been found only in the western part of the Dongying Depression in the Jiyang Depression,<sup>5</sup> located in the upper part of the Sha 4 member (called the Chunhuazhen group). Two types of organisms formed the reefs. One was a green algae called *Clado-siphonica sinica* with colony clusters. The other type was *Serpula*. There were also some other reef-building organisms of secondary importance. Many of the small reef bodies were mutually contraposed and developed within lagoons. Some confined small bays and became barrier reefs. The largest relic discovered is 49.5 meters thick and covers an area of over 100 square kilometers. It grew on a shallow-water platform in a lagoonal freshening stage. There are five subfacies sequences: lake basin sand, fore-reef zone, main reef body, back-reef zone and reef-back lagoon. Porosity and permeability are highest in the main reef body. Porosity is generally as high as 35.8 to 42.5 percent. The other subfacies zones are lower than this. These oil and gas pools are located mainly on top of the weathered crust of Lower Paleozoic sunken mountains, and the covering by the Chunhuazhen group forms a reef limestone oil and gas horizon.

Biogenic--oolitic beaches (bars) occur mainly in the Sha 1 and Sha 3 members, with some in the upper Sha 4 member. A single beach (bar) body usually covers several to several dozen square kilometers. The vertical profile is

# Four Types of Sand Body Sedimentation Patterns



formed of three parts, from bottom to top: 1) biogenic--oolitic--clastic bright crystalline limestone with organisms like snails, mussel-shrimp, algal detritus, etc.; 2) endoclastic limestone and gray-green mudstone; 3) muddy crystalline limestone (muddy microcrystalline dolomite and oil shale). The occurrence of clastic limestone is related to certain paleogeographic positions. It developed mostly at lake bay mouths and headlands, island and islet strands in the lakes, submarine platform slopes, island flats, and so on. The rich clastic accumulations were formed by wave action, which was determined by the direction and amount of winds. The particles underwent a certain amount of transport, sorting and rounding. Hydrodynamic energy was high on the stoss side of the islands. Oolitic particles developed and the organisms were fragmented. Biogenic limestone and bioclastic limestone developed on the leeward side of the islands. The oil and gas horizon is located in clastic limestone with primary pores. The porosity and permeability are fairly good, and there are high-yield oil and gas horizons. The oil and gas pools are in multiple overlapping layers leaning toward the uplift.

4. The sand bodies associated with fluvial deposits and the oil and gas pools that have rich accumulations of oil and gas occurrences in fluvial sands are secondary oil reservoirs. The channel sands have a typical normal cycle fluvial profile stratigraphic sequence. The main occurrences of oil and gas in channel sands are seen in upper Tertiary strata (Guantao group and Minghuazhen group). There are three conditions which control the distribution of oil and gas: 1) there should be a primary oil pool near the sand body and a fault which links them; 2) the oil-bearing horizon is interbedded sand and mud, the main channel sands are not entirely favorable; and 3) there is a trap like an anticline, fault trap, lens-shaped sandstone lithic trap, etc.

The above sand bodies have been proven by exploration to be petroliferous sand body types. The first two types are the most important. Littoral sedimentary bodies such as barrier bars along the shores of lake basin islands and islets also accumulated oil and gas to a certain extent, but it is not common and will not be discussed in detail.

### III. A Discussion of Problems in Oil Exploration

Based on the above understanding of Tertiary sedimentation in East China and the formational causes of sand body types, we should give consideration to the following problems in future continued exploration for Tertiary gas and oil reservoirs:

1. Based on the special developmental characteristics of the Tertiary fault basins in the east, we should pay close attention to the significance of rifting activity, the proximity of sediments to source area, and hydrodynamics. No broad flat alluvial plains developed on the strands of several of the eastern basins and depressions. For this reason, no large littoral sedimentary sand bodies formed. Strong flooding carried large amounts of high-density coarse detritus which was discharged directly into the lakes, forming density current deposits, the sediments being transported along the

lake bottom. For this reason, we cannot simply copy the distribution of oil and gas in marine facies strata and focus our attention on the coast. In the fault lake basins, we should pay attention to turbidity current sand bodies in deep depressions.

1). On the steep flanks of faults at the border of asymmetrical basins or depressions, if there is an inlet for an abundant source area, it will develop submarine alluvial fans, near-source deltas or other sand bodies. These types of sand bodies have already been proved to be areas of abundant accumulations of large oil pools, and should be an important direction for exploration. A fairly difficult question is how to use each of the various measures to find the inlets of source areas. A series of small conical bodies can also be found in several long and narrow fault basins or depressions and fault border zones. If these small conical bodies are oriented in the direction of the depression, large-area rimmed sand flats can occur. This type of sand body can have rich accumulations of large oil pools. The Dongpu Oil Field, for example, is of this type. The two conditions described above are favorable conditions that are created in the accumulation of large amounts of detrital sediments.

2). In regions with deep depressions, we should look for the occurrence of deep water submarine gravity flow channels distributed in lake bottom trenches. This type of sand body is often an extension of fan body channels in upstream submarine alluvial fans, and lake-bottom trenches also are often descended pan depression zones in rift zones. Thus, the basic direction to take in predicting the occurrence of this type of sand body is to locate the submarine fan of an upstream arenite inlet and then search for the related fault zone descended pan. In the Sha 3 member sedimentation period in the central and northern parts of the Huanghua Depression, for example, there are a series of submarine alluvial fan distributions. Moreover, the occurrence of one fan body has been proven, and an oil pool has been found. We can, therefore, predict the developmental tendencies of deep water channel sands.

The fault subsidence pan depression zones that occur at the border of the second-level structural zone are possibly ancient landforms of the lake-bottom trenches of geologic eras. For this reason, we should pay attention to making the second-level structural zone descended pans, fault traps and wedge-shaped protrusions the targets of exploratory drilling. Moreover, it is possible that various types of sand bodies have accumulated in downslope positions of the second-level structural zone. Paying attention to lithic upper-incline thinout and overlap zones is one exploratory direction to use in searching for non-structural oil reservoirs.

For the same reason, whenever deep-water channel sands or other landslip-type turbidite sand bodies are located, we should look for submarine fans, near-source deltas and other sand bodies in an upstream direction.

2. In the area of platforms without source areas within the basins, we should pay attention to searching for carbonatite-type oil pools. Among them, we should intensify research concerning the controlling developmental

conditions of ancient landforms toward clastic limestone. Examples are baymouths, headlands, sand spits, submarine island flats on the slopes of ancient islands, underwater platforms, and so on. Because the water was shallow, there can be rich detritus accumulation strata if there are just micro-landforms and minute hydrodynamic action. We should also study the different energy zones influenced by different ancient wind directions. Analytical forecasts have been done to different degrees on this question in the Jiyang and Huanghua depressions.

3. In the search for Tertiary oil reserves in eastern China, we should also pay sufficient attention to exploration for the objective strata in the Sha 4 member. It has now been proven that the Sha 4 member has oil and gas, but the scope of occurrence is relatively small. This is because the Sha 4 member distribution must be smaller in scope than the later sediments. The ancient landforms of the Sha 4 member are relatively complex, and there is even greater segmentation and differentiation. The sediments are fairly thick and the water bodies were perhaps quite deep. Indications of this type of condition have been found in the Dongming depression, usually having developed within a deep-water channel or deep depression. The primary areas of exploration at present are in the Jizhong (Central Hebei) and Dongming depressions. The Jiyang and Huanghua regions may be slightly deeper and make exploratory drilling more difficult.

In summary, there is a great potential in further searches for Tertiary oil and gas reservoirs in the eastern part of China. The opinion that "almost all of the eastern Tertiary oil pools have already been found" is insufficient. The potential lies in further development of exploration for non-structural oil pools and in gaining a better understanding of the sedimentary and petroliferous conditions of deep strata. Searches for the Tertiary target strata are of greatest real importance. In order to create a new situation in Tertiary oil exploration, we must strengthen and strive to develop research on sedimentary environments and the reasons for sand body formation. We must first of all gain a clear understanding of the sedimentary structure of the strata of each period in the basins and use the concepts of sedimentology to re-evaluate the prospects for oil and gas. We should adopt many different measures to do research on sand body distributions, search for regularities in rich accumulations of oil and gas, and do research on the non-structural entrapment conditions that occur in sand bodies. This will point out the directions for oil exploration.

#### FOOTNOTES

1. The main concepts of this article were reported at the Second Annual Meeting in Changsha in 1981.
2. Chen Fajing [7115 4099 2529] and Wang Defa [3769 1795 4099], "Types of Sediment Formation in China's Tertiary Oil- and Gas-Bearing Basins," DIZHI XUEBAO [Journal of Geology], No 3, 1980 pp 208-217.

3. Sun Yongchuan [1327 3057 0278], Zheng Junmao [6774 3182 5399], Wang Defa and Li Huisheng [2621 1920 3932], "Submarine Alluvial Fans--A New Realm For Oil Exploration," KEXUE TONGBAO [Science Bulletin], No 17, 1980 pp 799-801.
4. Zhang Fumin [1728 2591 3046] and Jian Zongyu [4675 1350 3842], "Special Characteristics of Tertiary Sedimentary Development and Environments in the Huanghua Fault Basin," SHIYOU YU TIANRANQI DIZHI [Oil and Gas Geology], No 2, 1981 pp 141-156.
5. Shengli Oil Field Exploration and Development Planning and Research Institute, "Special Petroleum Geology Characteristics and Regularities in Oil and Gas Accumulation in the Jiyang Fault-Block Basin," 1977.
6. H. G. Reading, "Sedimentary Environment and Facies," 1978.
7. Albert Matter and M. E. Tuoker, "Modern and Ancient Lake Sediments," 1978.

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## OIL AND GAS

### OIL PROSPECTS FOR THE HUAHAI-JINTA BASIN

Jiangling SHIYOU YU TIANRANQI DIZHI [OIL AND GAS GEOLOGY] in Chinese Vol 4, No 3, Sep 83 pp 318-323

[Article by Xie Gongjian [6200 1872 0313], Huabei Research Institute of Petroleum Exploration and Development: "Oil Prospects in the Huahai-Jinta Basin"]

[Summary] The Huahai-Jinta Basin in northern Gansu is a 9,688 sq km area of sedimentary rock 5,000 m thick. The rocks are primarily Jurassic, Cretaceous, and Tertiary rocks on Lower Paleozoic basement rock. Surface geological surveys and test drilling found no oil. However, oil producing conditions, accumulation conditions, and evidence of oil and gas all indicate that the prospects for finding oil and gas in this basin are good.

First of all, oil producing conditions are good. The oil producing matter is thick Cretaceous lacustrine black and grey mudstone 700-800 m thick, thinning to 300 m in the surrounding area. The oil producing rock area is thus 400-633 km<sup>2</sup>. There is also evidence of rich organic matter: samples from 5 wells contained an average of 2.86 percent organic matter, hydrocarbon content of the rock is about 1,000 ppm, with the lowest level at 260 ppm, and the chloroform pitch "A" averages 0.224 percent. All this indicates that during the Cretaceous, the basin was a damp deep to semi-deep lacustrine environment with sufficient organic sources to produce abundant petroleum. The basin was also a stable reductive environment as evidenced by iron content. Finally, the necessary conversion conditions existed. The sedimentary rocks in the Huahai Depression are about 5,000 m thick. Huashen Well No 1 was drilled to a depth of 3,233 m without going through the Cretaceous layer. Black mudstone may be 3,100-3,200 m deep. The threshold depth for oil generation is about 1,800 m. In terms of hydrocarbon content, chloroform pitch "A" average, and OEP value, the Huahai-Jinta Basin matches other oil-bearing basins in China. The temperature gradient is 2.53°C/100 m which compares favorably with the oil field temperature gradient for Western China (2.2-2.3°C/100 m).

There are two areas which are high in percentage of arenaceous rock: between Huashen Well No 1 and Hua Well No 5 and between Hua Well No 12 and Hua Well No 11. Permeability ranges from a low of 1 md in the area between Huashen Well No 1 and Huashen Well No 6 to a high of 187-1,157 md in the area from

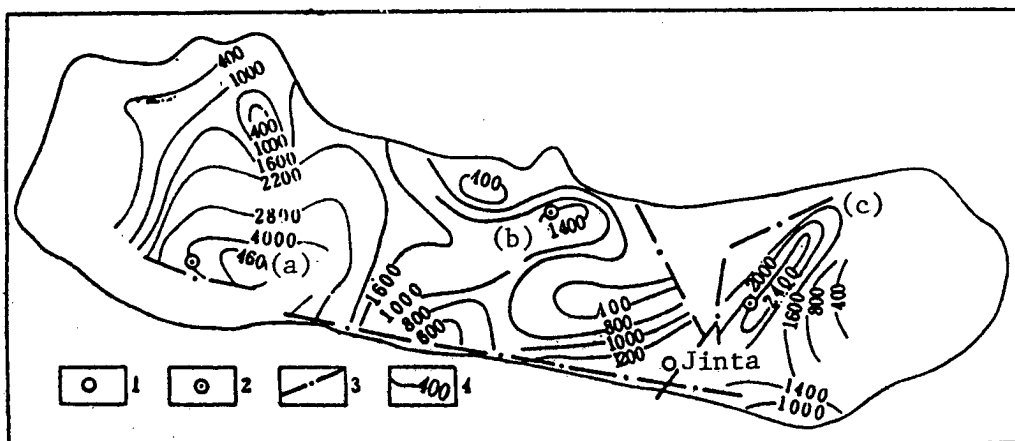


Figure 1. Huahai-Jinta Basin Basement Rock Isobath Map

Key:

- |   |                             |
|---|-----------------------------|
| 1. County                               | a. Huahai Depression        |
| 2. Key well                             | b. Shengdiwan Depression    |
| 3. Inferred fault                       | c. Shuanggucheng Depression |
| 4. Basin basement rock isobath (meters) |                             |

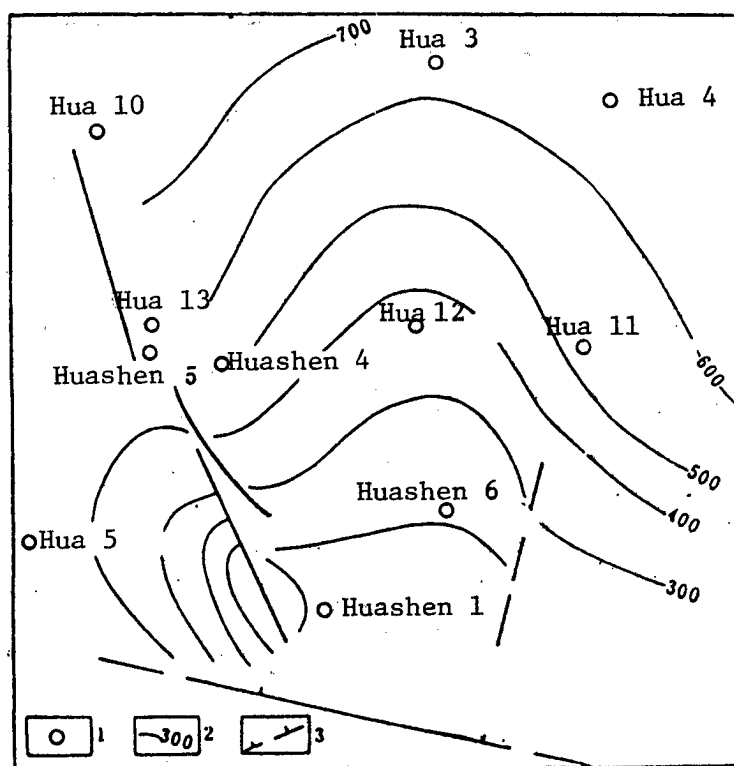


Figure 2. Huahai Depression T<sub>5</sub> Structure Map

Key:

1. Well location
2. Seismic T<sub>5</sub> reflection layer (Tertiary plane) contour lines (meters)
3. Fault

Table 1. Divisions of Oil Producing Zones and Canlaogen [1626 6803 2704] Evolutionary Stages of Xinmin Baoqun [2450 3046 1027 5028] ( $K_1x_1^3$ ) Beneath the Huahai-Jinta Basin

Evolutionary process of organic matter		Canlaogen evolutionary stages	Rock formation zone classification M. Shibaoka et al	Petroleum "liquid window" W. C. Puser III	Coalification stage Rm %
Changes in No/gr of free radical parametric center reflection in ganlaogen with depth	Pure coal Rm %				
	1500 1500	Relative stability stage	Pre-oil formation zone	Liquid window	0.56 I
	- 0.50 -	Depolymerization stage	Early		
	2000 2000		Oil-producing zone		
	- 0.70 -	Middle			
	2500 2500	Splitting stage	Late		
- 1.00 -	Splitting-re-polymerization balance stage.	Condensate			- 1.08 III
	3000 3000				- 1.36 IV

(After Qian Jisheng [6929 0679 4141])

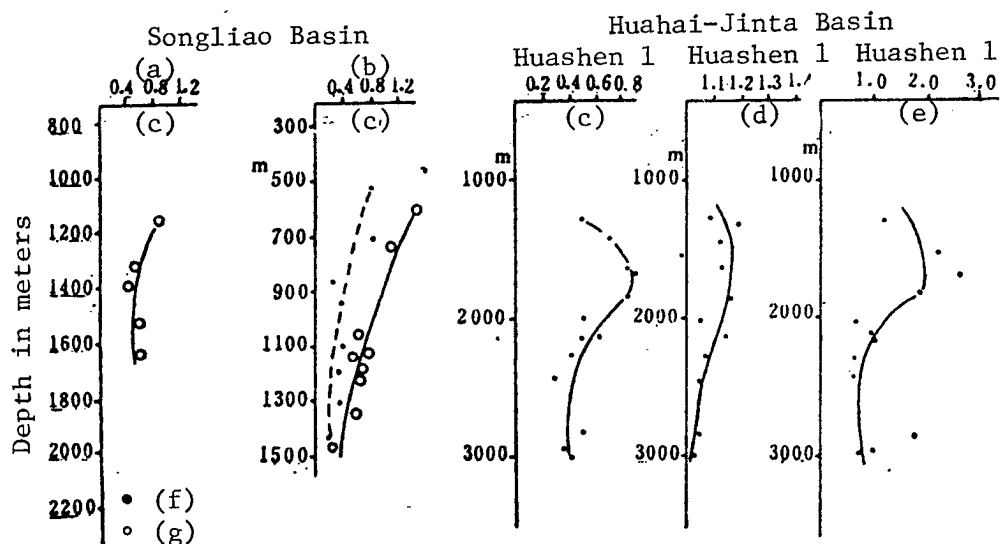


Figure 3. Comparison with Songliao Basin of Curve of Changes with Depth of 3 Geochemical Indicators from Huashen Well No 1

Key:

- a. Qingshankou Group, Sections 2, 3
- b. Nen Section 1
- c. Arene structure coefficient
- d. Parity superiority
- e. Qusu [0648 4799] ratio
- f. Shallow water-swampy dark colored mudstone
- g. Deep-relatively deep water dark colored mudstone

Table 2.

<u>Well number</u>	<u>Huashen 1</u>	<u>Hua 5</u>	<u>Hua 1</u>	<u>Huashen 6</u>	<u>Huashen 4</u>	<u>Huashen 5</u>	<u>Hua 12</u>	<u>Hua 10</u>	<u>Hua 3</u>	<u>Hua 14</u>
Reservoir thickness (m)	763	225	34.5	251	269	315	432	464	258	106
Total thickness of sand and mudstone (m)	1,067.42	247.17	34.5	1,290	649	864	531.51	806	510.56	199.5
Percentage of arenaceous rock	72	91	100	19.5	41	36	81.3	57.5	50	53.1

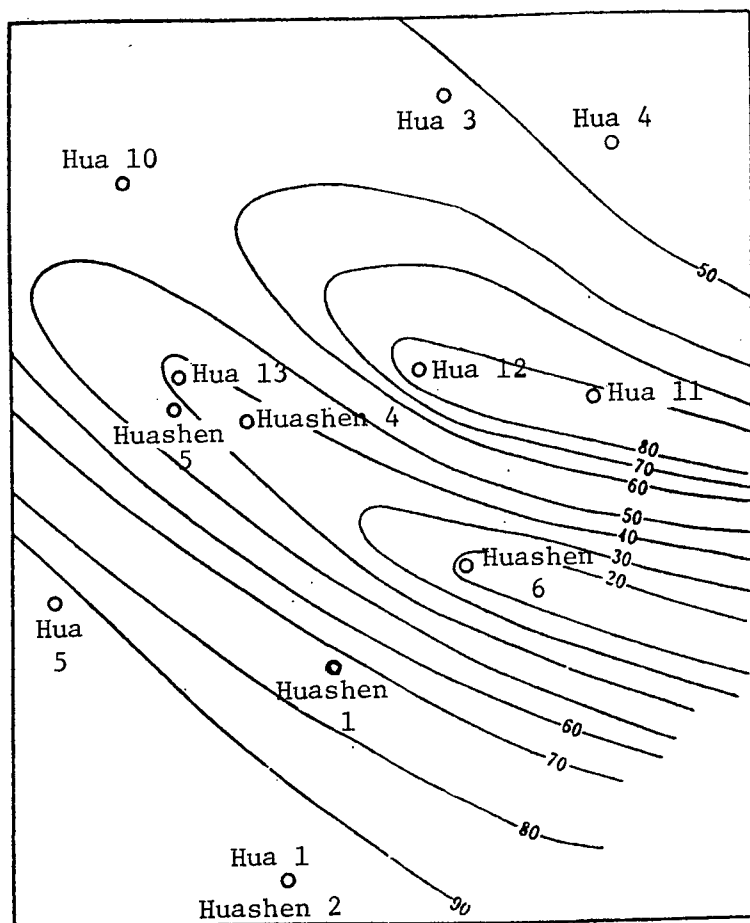


Figure 4. Map of Percentage of Arenaceous Rock

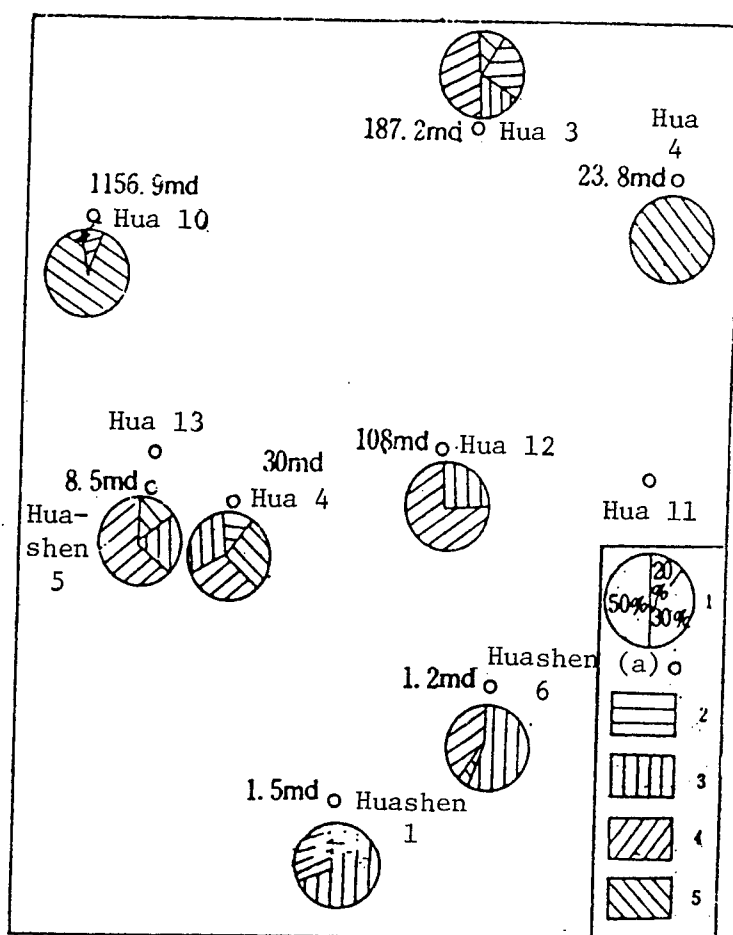


Figure 5. Sandstone Permeability and Fluorescence Evidence Distribution

Key:

1. Percentage of fluorescence levels
2. Above level 10
3. Levels 7-10
4. Levels 5-7
5. Below level 5

(Based on materials from the Yumen Petroleum Management Bureau)

a. Permeability o Well number

Table 3.

Well number	Total No of evidences (places)	Pitch (places)	Oil (places)	Oil smell (places)	Notes
Huashen 1	715	27	622	66	
Huashen 4	29	14	13	2	
Huashen 5	43	5	38		
Huashen 6	81	16	43	22	
Hua 12	6		6		
Hua 3					
Hua 5					Fluorescence evidence Fluorescence evidence

Oil produc-			
Stratum	Depth (m)	ing or storage layer	Type or No of evidences*
Tertiary	1197	Storing	
	1211	Producing	
Cretaceous	1269		oo oo
		Storing	
	1494	Producing	
	1557		vvvvvvvvvvvv vvvvvv vvevvv vvvvvv vvvvvv

Figure 6. Distribution of Huashen Well Number 1 Oil and Gas Evidences  
(according to core materials figures, not complete recording of  
evidences for the well)

Hua Well No 10 and Hua Well No 3. There are two areas of high fluorescence levels: one where 59.3-98.2 percent of the wells are from 7 to above level 10 and the other where 40-46.6 percent are from 7 to above level 10. All this indicates that there are several good collection areas in the basin. There are several areas of good sandstone of sufficient thickness. Sand layers are generally 1-5 m thick, with the thickest being 7.2 m. In addition, in areas of low permeability there are also some strata of high permeability. There is also a sufficient amount of cracking and fissuring to make the rock oilbearing.

Evidence of gas and oil has been discovered in several wells. In the Huashen Well No 1, for example, there was oil and gas evidence in more than 715 places, including some relatively concentrated areas. In addition, below 1,940 m there were varying degrees of oil and gas invasion. Beneath the basin is a central depression and it is bordered on three sides by faults varying in length from 7 to 20 km.

The prospects for finding oil in the Huahai-Jinta Basin are good. The basin is large, oil producing layers are very thick, and the geological structure of the basin provides conditions favorable for forming oil traps and various kinds of oil reservoirs. It is also an easy area for prospecting since it is relatively flat and communications are good. There are some problems, however: the oil traps are not well founded, the deep strata have not yet been studied well and the second level structures still cannot be correctly delineated. In addition, the lithic nature of the lithofacies has changed greatly, faults are developing, and there are also many problems with the crust, the lithofacies, and structure. The author then goes on to point out several sites where oil deposits are most likely to be found.

8226

CSO: 4013/66

## OIL AND GAS

### CHINA LAUNCHES FIRST DOMESTICALLY BUILT SEMISUBMERSIBLE

OW220018 Shanghai City Service in Mandarin 1100 GMT 19 Jun 84

[Text] A ceremony was held in Shanghai Shipyard this afternoon marking the completion of the "Kantan-3" oil rig. Amid warm applause and with the beating of drums and gongs, Vice Mayor of Shanghai Li Zhaoji cut the ribbon for the completion of the oil rig. Invited to attend this ceremony were (Pan Mutan) of the State Economic Commission; (Dai Feng), vice minister of geology and mineral resources; (Zhang Yongxian), vice chairman of the board of directors of the China State Shipbuilding Corporation; Pan Zengxi, deputy general manager of the China State Shipbuilding Corporation; Zhou Chuanru, general manager of the China National Machinery Import and Export Corporation; (Chen Dehong), deputy director of the State Oceanography Bureau; and the consul-generals and vice consul-generals of the U.S., Japanese, French, FRG and Polish consultates-general in Shanghai, totaling some 300 people. Congratulatory messages were sent in from State Councillor Kang Shien, and the leading comrades of the State Economic Commission, the China State Shipbuilding Corporation, and the group for the development of coastal oil fields under the Ministry of Petroleum Industry.

The "Kantan-3" is the first semisubmersible oil drilling rig, designed and built by China itself. Equipment of high international standards has been installed on the oil rig for power generation, oil drilling, positioning, and combating hurricanes and strong waves. The oil rig is also equipped with a "Dauphin-2" helicopters.

The oil drilling rig was checked by the State Ship Examination Bureau and the U.S. Shipbuilding Association and proven to be of high quality.

CSO: 4013/189

OIL AND GAS

SEARCH FOR NEW OIL FIELDS IN HEILONGJIANG CONTINUES

OW191224 Beijing XINHUA in English 1131 GMT 19 Jun 84

[Text] Harbin, 19 Jun (XINHUA)--China's biggest oil-producer is trying to find another big oilfield similar to Daqing by the year 2000, the mayor of Daqing, in China's northernmost Heilongjiang Province, told reporters here.

Daqing has pumped out more than 50 million tons of crude oil annually since 1976, accounting for 50 percent of the national total.

Mayor Zheng Yaoshun said large-scale exploration in the past few years had uncovered many new oil-bearing zones.

Exploration since 1959, when the oilfield was developed, had put Daqing's known reserves at 3.5 billion tons, but so far only about 700 million tons had been pumped out, the mayor said.

Five known oil-bearing zones had not yet been put into production, said Liu Dingzeng, of the Daqing Exploration and Development Research Institute.

He said the most advanced methods would be used to developing the oilfield.

CSO: 4010/110

## OIL AND GAS

### SHENGLI OILFIELD REPORTS RECORD PRODUCTION

OW020750 Beijing XINHUA in English 0701 GMT 2 Jul 84

[Text] Jinan, 2 Jul (XINHUA)--The Shengli oilfield, China's second largest, pumped out 59,500 tons of oil a day in June, or 20 percent of the nation's daily output, officials said.

The oilfield, in Shandong Province, also set records in major production quotas in the first half of 1984, they said.

Oil production was 10.34 million tons during the period--a 16.7 percent rise over the same period of 1983. Industrial output was valued at 1.1 billion yuan (about 500 million U.S. dollars), an increase of over 16 percent. A total of 6,800 kilometers of seismic lines were shot, up 108 percent, and drilling footage reached 924,000 meters, up 62 percent.

The Shengli oilfield has sunk 70 new wells this year, each producing more than 50 tons of oil daily. Of these, seven wells are reported to be pumping out more than 1,000 tons a day.

A total of 235 new wells went into operation in the first 6 months of this year, oilfield officials said.

This year, China had produced 53.83 million tons of crude oil by 25 June, meeting its semi-annual plan t days ahead of schedule. The figure represents a 6.1-percent increase over the same period of 1983.

CSO: 4010/110

## OIL AND GAS

### BRIEFS

LIAONING REPORTS ANOTHER BIG OIL AND GAS STRIKE--Shenyang, 19 Jul (XINHUA)--An exploratory well in the Liaohe oilfield in Liaoning Province produced 1,306 tons of crude oil and 70,000 cubic meters of natural gas in a 24-hour test this week. This is the second high-yield oil well in the granite oil-bearing zone of the Shenyang exploration area, an oilfield official said today. Liaohe oilfield [drilled] an exploratory well last April with a record daily output of 1,503 tons of crude oil and 95,029 cubic meters of gas. The high output of the new well, 3,777 meters deep, verifies the rich resources in the exploration area near the provincial capital. Covering an area of 12,400 square kilometers, the Liaohe oilfield has a verified reserve of more than 600 million tons of oil and 34.8 billion cubic meters of gas. There are 1,554 oil wells and 111 gas wells in operation there, the official said. The oilfield produced 6.1 million tons of crude oil last year, against 2.54 million tons in 1977. [Text] [OW191537 Beijing XINHUA in English 1434 GMT 19 Jul 84]

TIANDONG NOW IN PRODUCTION--The Tiandong oil field which was discovered in the Baise Basin in Guangxi Province is now in production. Over 90 wells have now been sunk, of which 65 are producing oil or gas. Today, the Guangxi Petrochemicals Industries Company is actively developing exploration in an effort to produce over 100,000 tons of crude a year within 2 to 3 years to provide a new energy base for energy-short Guangxi. [Text] [Beijing RENMIN RIBAO in Chinese 19 Jul 84 p 1]

CSO: 4013/210

## NUCLEAR POWER

### DEVELOPING NUCLEAR ENERGY: A MAJOR STRATEGY IN CHINA'S ECONOMIC CONSTRUCTION

Beijing HE KEXUE YU GONGCHENG [CHINESE JOURNAL OF NUCLEAR SCIENCE AND ENGINEERING] in Chinese Vol 4, No 1, Mar 84 pp 1-4, 15

[Article by Jiang Shengjie [5637 5110 7132] of the Ministry of Nuclear Industry received on 8 Nov 83: "Developing Nuclear Energy Is a Major Strategic Measure in Economic Construction in China"]

#### [Text] Abstract

The circumstances of the development of China's energy resources and the conditions of developing nuclear energy in China were analyzed. It is pointed out that developing nuclear energy is a fundamental strategic measure to solve the energy shortage in China. It is also an effective way to alleviate the energy deficiency in areas where transportation is in short supply. The technical policy for developing nuclear energy was presented.

For several thousand years, there were four major breakthroughs in understanding and utilizing energy resources by mankind, i.e., utilization of fire, discovery of steam engines, availability of electricity and development of nuclear energy. Each major breakthrough had a major promotional effect on the development of the national economy and progress in science and technology. The development of national economy, however, requires more energy. Hence, the consumption of energy in the world is rapidly increasing. In 1950, the total energy consumed in the world was equivalent to 2,600 Mt of standard coal. In 1970, it reached 8,500 Mt of standard coal. It increased dramatically to 9,800 Mt of standard coal in 1979 and it is estimated that it will reach 20,000 Mt of standard coal by the year 2000. By the year 2020, the world's energy consumption will be equivalent to 34,000 Mt of standard coal. The total reserve of petroleum and natural gas, however, is limited. Based on the present consumption rate, production will begin to decline after 1995, [and resources will] be exhausted in several decades. All the nations generally believe that coal is one of the most useful energy resources to replace petroleum in the short term. Therefore, coal production will increase significantly and reach a saturation point by the middle of the next century, still occupying around 25 percent of the energy resources. As for hydropower, 370,000 MW has already been developed in the world, and it will be fully developed by 2020. In view of the status of energy,

it is generally believed that the nuclear energy series represented by thermal neutron reactors, fast neutron breeder reactors and controlled fusion reactors is the most promising new energy source. It may become the major future energy resources for the mankind because thermal neutron reactors are applied in a large scale, fast neutron breeder reactors are already in an industrial demonstration stage and will be commercialized in the near future. These two types of reactors alone can ensure the needs of mankind for several hundred years. Fusion reactors use deuterium in seawater as the fuel. One ton of seawater contains deuterium equivalent to 350 t of standard coal in energy. The deuterium in seawater is inexhaustable. Fusion reactors can support the mankind for billions of years. Once it is successful, the energy resource problem is basically solved.

## I. Developing Nuclear Energy - Trend of Energy Development in the World

Since the world's first nuclear power station (5000 kW power) was put on line in 1954 in the USSR, nuclear power has been widely developed. Many national and international energy resources research institutions generally believe that developing nuclear energy on a large scale is a fundamental measure to solve the energy problems in various countries and in the world during the latter part of this century and the early part of the next.

According to statistics in the August 1982 issue of the West German magazine Nuclear Industry and Nuclear Technology, the world has 273 nuclear power stations in operation. The total generating capacity reached 168,000 MW, which is over 8 percent of the capacity of the power stations in the world. There are 290 nuclear power stations under construction. In addition, 110 units are being planned. These nuclear power stations are located in 35 countries and areas in five continents. In addition to a considerable number of nuclear power stations already built in major developed nations such as the US, England, the USSR, France, West Germany, and Japan, developing nations are also urgently building nuclear power stations. Today, Yugoslavia, India, Argentina, Pakistan, Brazil, and South Korea have already constructed nuclear power stations. Over a dozen countries, including Romania, Egypt, and Mexico, are planning to build them. It is estimated that approximately 40 countries in the world will own nuclear power stations by the end of the century. The nuclear power generating capacity in most developed nations will reach 20-30 percent or more of the total power generating capacity.

It is worthwhile noting that not only the nations with little fossil fuel resources, such as Japan and western European countries, must rely on developing nuclear power to solve energy problems but also countries with abundant coal, petroleum, natural gas and water power resources such as the U.S., the USSR, and Canada have huge nuclear power development plans.

Given continuously increasing demand for energy resources, unstable petroleum prices and supplies, depletion of fossil fuel resources, and the as yet under-developed large-scale commercialization of other energy resources, developing nuclear power is a technological policy adopted by various countries after studying the situation and prospects of energy resources.

## II. Developing Nuclear Energy - A Must for China Given the Status of Its Energy Resources

The supply and demand of energy resources is a contradiction which seriously affects the development of the national economy. Internationally, nuclear power plants have reached a commercial stage. The technology has matured, and is safe, reliable and economically viable. It has become the only new energy resource capable of alleviating the energy shortage on an industrial scale.

### 2.1 China Is One of a Few Major Energy Producing and Consuming Nations in the World

China is the world's largest energy consuming country. However, the average energy consumed per capita is very low. In 1980, the energy consumed per capita was only 610 kg of standard coal, which is only one-quarter of the average world level. Urban residents in China only consume 12 kilowatt-hours per capita per year, which is only a fraction of that in a developed country.

Most of the areas in China are short of electricity. Due to the power shortage, factories in many provinces are forced to stay open for 4 days and shut down for 3, or operate for 5 days and close for 2. In recent years, the power shortage per year was 40-50 billion kilowatt-hours, leading to a reduction of more than 20 percent in industrial productivity.

### 2.2 Demand for Energy Resources by the Grand Objective of Quadrupling the Economy

The twelfth conference of the Chinese Communist Party called for the quadrupling of agricultural and industrial production by the end of this century. It is a magnificent strategic goal. From the economic growth rate, it must grow by more than 7 percent per year. Until the year 2000, total energy production will only increase a little more than one-fold as compared to that in 1980. However, the growth rate of power generation must coincide with the rate of industrial growth. Electricity must also be quadrupled; 75 percent of the power generated in China will be produced by burning coal. Even if coal consumption is reduced by upgrading old plants technologically, there will be a shortage of 0.4 billion tons of standard coal before year 2000.

### 2.3 Uneven Distribution of Conventional Energy Resources in China Limits Production Development

Because of the extremely uneven geographic distribution of energy resources, there is a shortage of available transportation--a major constraint limiting the development of energy production. Today, transporting energy resources in China occupies 43-47 percent of the total national transportation capacity. We should accelerate developing and utilizing various energy resources, especially nuclear energy, in order to satisfy the strategic goal of quadrupling the economy.

Therefore, the energy structure should be changed in areas of shortage to provide electricity and heat by nuclear energy. Whether from the technological and

economic viewpoint or from the environmental protection angle, building large nuclear power plants in these areas is an important way to ease the energy shortage.

#### 2.4 Nuclear Energy Heating Opened New Territory in Nuclear Applications

There is a shortage of petroleum resources in China, and the country has adopted a policy to curtail the burning of oil. In this context, the potential savings in "replacing oil with nuclear" are very large. It is new territory in nuclear energy applications.

Presently, most fuel consumed is not for generating electricity. Approximately 70 percent is used for industrial and residential heating. Because of the worsening shortage in petroleum and the desire to export more petroleum to obtain more foreign exchange, we are investigating the use of coal or nuclear energy to provide heat. The transmission of thermal energy, however, is more difficult. It will be necessary to adopt a relatively small-scale plant to generate both heat and electricity by nuclear power. In addition, the thermal efficiency of a nuclear power plant is only around 30 percent, while it may reach 90 percent for a nuclear plant designed for both heat and electricity. Such medium or small-scale nuclear plants can still be economically viable despite the higher construction cost per kilowatt. We are considering plans to supply industrial steam to large petrochemical plants by using nuclear energy. For example, Jinshan Petrochemical Plant in Shanghai requires a great deal of steam (approximately 500 t/h). Originally, this steam was supplied by an oil-burning furnace. Although we had considered using coal to replace oil, due to difficulties in transporting the coal and the possible detrimental effect on the quality of products from ashes and harmful gases released by burning coal, a plan to construct a small 450 MW nuclear heating plant was proposed to replace oil. In order to ensure the reliability of steam generation, two reactors will be built simultaneously, capable of producing  $2 \times 500$  t/h of saturated steam at a pressure of 16 kg/cm<sup>2</sup>. This heat supplying power plant plan has already been received and approved.

#### 2.5 China Already Has Basic Conditions To Develop Nuclear Power

After 27 years of hard work, the nuclear energy industry in China has reached considerable proportions. A relatively complete scientific research and industrial system has been established. It is the foundation of military nuclear energy in China, as well as a sound basis for developing nuclear power.

In the aspect of uranium ore, preliminary exploration of reserves to date indicates that, in addition to satisfying military use, they are sufficient to operate pressurized-water reactor power plants representing 15,000 MW in installed capacity for over 30 years. Furthermore, there are still vast areas not yet surveyed. It is estimated that new ores can still be discovered. Technologically, China has the capabilities to exploit and smelt uranium ores, separate isotopes, fabricate fuel elements and process spent fuels. China has constructed and operated over a dozen experimental, production, and small power reactors, with experience in designing, installing, operating, and modifying reactors. A number of technical teams have been developed. The foundation of

building the equipment for a large nuclear power plant is also quite good. The production techniques of special structural materials used in reactors have also been mastered.

### III. Nuclear Energy Development Policy in China

Developing nuclear energy is a long-term strategic measure to solve the problem of energy resources in China. It is also an effective way to alleviate the shortage of transportation in energy deficient areas. The conditions to develop nuclear power in China have matured. Premier Zhao announced in the First Conference of the Sixth People's Congress that "China will speed up developing the power industry from the standpoint of thermal power, hydroelectric power, and nuclear power." Recently, the state invited experts from around the nation to fully demonstrate our nuclear power policy. The experts unanimously believed that:

- (1) China should choose pressured-water reactors in the class of light water reactors as the basic reactor type in first generation nuclear power plants before the year 2000.
- (2) The single reactor power level in a Chinese nuclear power plant should be on the order of a million kilowatts.
- (3) China already has the ability to develop nuclear power plants alone--300 MW prototype reactors have already been built. However, in order to speed things up, it should be ready to import foreign technology and equipment for larger nuclear power plants. Through its own scientific research, foreign technology will be digested, absorbed, and mastered. On this basis, we should create and develop our own technology to quickly realize domestic production of nuclear power plant equipment and build our own civilian nuclear industry system.
- (4) In industrially developed but transportation-poor areas along the coast in China, a larger effort will be aimed at developing nuclear power. By the end of this century, China may build nuclear power plants up to 10,000 MW.
- (5) The fuel for nuclear power plants must originate from inside China. It is necessary to produce more concentrated uranium to ensure the supply of fuels to nuclear power stations. To this end, we must develop the centrifuge method. Prospecting for uranium ores must be accelerated and economically viable reserves must be expanded. Scientific research related to the survey, exploration, and exploitation of uranium mines must be carefully managed.
- (6) In order to conserve natural uranium and separation power, preparation should be made ahead of time to process spent fuel elements in civilian power generating reactors (to separate the uranium and plutonium for recycling).
- (7) Most of the fossil fuels in China are used for heating. The utilization efficiency is very poor. It is an effective way to solve the power shortage in energy deficient areas by "using nuclear instead of oil" and "using nuclear instead of coal." Therefore, the reactor technology already under control in China should be used to study heat supplying nuclear power stations and regional

low-temperature heat supplying nuclear power stations. The treatment and final disposition of radioactive wastes produced by nuclear power plants should be actively investigated.

#### IV. Exploitation of Nuclear Energy Technology and Outlook of Its Utilization

There should be a long-range plan for developing new reactors. A special fund is budgeted based on the principle of spending less and doing more. Furthermore, international collaboration should be fully utilized to prepare the technological work in order to catch up with further development in nuclear energy.

- (1) From the long-range requirement of nuclear energy development, it is necessary to build fast breeder reactors immediately in order to fully utilize  $^{238}\text{U}$  which exists above 99 percent in natural uranium as the energy source. We must intensify our scientific research on fast breeder reactors by the year 2000 in preparation for the construction of commercial reactors in the 21st century.
- (2) The high-temperature air-cooled reactor is a new multi-purpose reactor capable of providing heat for high-temperature technologies. Furthermore, it can be used in the gasification and liquefaction of coal. Research should be started right away.
- (3) The use of controlled fusion is a long-term direction in energy development. The experimental research on controlled fusion must be strengthened. A policy to link Chinese research with international exchange and cooperation should be accepted. During the "Seventh Five-Year Plan" period, design indicators for the "451" Tokamak already built should be met in order to prepare for the construction of an experimental ignition fusion apparatus.

In early 1980, there were great differences in opinion as to whether nuclear power should be developed. After over 3 years of investigation and demonstration, the viewpoint has become almost unanimous. It is generally believed that nuclear power is an important energy resource second only to coal and hydroelectric power in order to realize the goal of quadrupling the national gross product by the end of this century. Developing nuclear energy is an important strategic measure in the economic construction in China. A long-term plan for developing nuclear power should be drawn up and included in national economic planning. This planning should formulate the scale and rate of construction of nuclear power plants from a national angle, the technical path, the correlation between imported technology and developments made in China, the procedures to produce the equipment in China, and the sources of capital and personnel. The most important thing is to determine the overall objective of nuclear power development. It should be developed immediately in energy deficient areas such as Huadong, Dongbei, and Guangdong to alleviate the shortage and to contribute to the economy and personal income of the people. Furthermore, it acts as the foundation for the further development of nuclear energy in China in this century.

## NUCLEAR POWER

### ECONOMIC ADVANTAGES OF NUCLEAR VS. COAL-FIRED POWER PLANTS WEIGHED

Chengdu HE DONGLI GONGCHENG [NUCLEAR POWER ENGINEERING] in Chinese Vol 4, No 6, Dec 83 pp 43-50

[Article by Luo Anren [5012 1344 0088]: "An Economic Comparison Between Nuclear and Coal Power Plants in Southeast China"]

[Text] The supply of energy in southeast China has been strained for a long time. Construction of nuclear power plants in this area may be a major way to ease this situation. Therefore, it is necessary to make an economic comparison between the nuclear and the coal-fired power plants constructed in this area. In this article, such a comparison is made by using the updated economic data and the tentative criteria issued by the Ministry of Electric Power Industry in 1982. Once we have mastered the construction technology of nuclear power plants, our 1,000 MW nuclear power plants would be more economical than coal-fired power plants of the same capacity, but the 300 MW and the 125 MW nuclear power plants will not be as economical as the coal-fired power plants.

#### I. Preface

The lack of energy resources in the coastal industrialized areas of our country is serious, and hinders the growth of our national economy. Constructing nuclear power plants in these areas is an effective way to ease this serious energy shortage. But in the seventies, due to the fact that there was a misunderstanding by certain leading cadres towards the economic value of constructing nuclear power plants in our country, they thought that the investment spent on constructing a nuclear power plant would have been enough for constructing several coal-fired power plants of the same capacity. Therefore, the development of nuclear power enterprises was hindered. In 1980, after exhaustive investigations and analyses were carried out by the Nuclear Energy Investigation and Research Group of the State Scientific and Technological Commission, it was concluded that while we had the technology to construct nuclear power plants, the difference in investments, together with the investments in the systems needed for the maintenance of the operation between the large nuclear power plants in the southeast and the coal-fired power plants of the same capacity is negligible. In fact, the cost of generating electricity by the nuclear power plants is slightly lower than that by the coal power plants.<sup>(1)</sup> Reference (1) primarily clarifies the

misunderstanding towards the economic value of nuclear power engineering in our country, but there are some inadequacies in the contents of this reference. First, there is no discussion and demonstration on the economic value of constructing 100 MW and 300 MW nuclear power plants in our country. Second, the data used in the reference were mostly based on economic parameters before 1979. Due to the fact that the price increase during the past few years has been higher than before, rectification is needed for a lot of these data. Third, the "Comparison Standard for Discussion on and Demonstration of Power Plant Projects" was drawn up by the Ministry of Electric Power Industry in early 1982. It is necessary to make the economic comparison between nuclear and coal-fired power plants according to this standard. Based on this, it is our purpose to make further comparisons and analyses on the economic value of nuclear and coal-fired power plants in southeast China.

## B. Primary Data and Calculation Methods for the Cost of Generating Electricity

### 1. Capital Investment Data

#### (1) Power Plant Construction Cost

Table 1 shows some of the technical and economic parameters of nuclear power plants constructed by our own country. A few comments should be stated as follows:

China has never built a nuclear power plant over 1,000 MW and even design documents for these power plants are not available. Therefore, only a rough cost analysis can be made. In 1982, based on the reference of the costs of different equipment for large-size nuclear power plants abroad, a cost estimate of manufacturing the equipment by ourselves was done by a joint

Table 1. The Technical and Economical Parameters of the Pressurized-Water Reactor [PWR] Plants Built by China

<u>Parameters</u>		Gross Power, kW		
		100	30	12.5
Investment per kW (including fuel)	yuan/kW	1,500	2,200	2,340
Nuclear Fuel Consumption	MW-day/ton	38,000	24,210	26,000
Thermal Efficiency (net)	%	33.8	27.5	25.6
Capacity Factor	%	70	70	70
Percentage of Electricity Consumption by the Plant	%	5	7	7

working group organized by the China Electrical Engineering Society, the China Nuclear Society, and the China Mechanical Engineering Society. In addition, cost estimates needed for constructing a large nuclear power plant (excluding the equipment cost) were made based on the costs of building construction and installation of the Southern Jiangsu Nuclear Power Plant, once planned to be built in 1979. After some adjustments were made on the construction cost analysis performed by the joint working group, we think that while we will have the technology to construct large nuclear power plants in the nineties, the investment per kW (excluding the fuel cost) should be in the range of 1,200 - 1,450 yuan/kW, provided that they are constructed in serial production. The calculations were based on average values and then subjected to analysis.

According to the design data of our 300 MW and 125 MW PWR power plant projects, the investment per kW (including the fuel cost) of our first nuclear power plants was 2,500 yuan/kW and 2,130 yuan/kW respectively. Choosing the value of investment per kW as 1,500 yuan/kW for the 1,000 MW nuclear power plant was based on the condition that they would be in serial production after the technology to construct them has been acquired. Therefore, some adjustments should be made on the investment per kW of the medium and small nuclear power plants.

Considering that the cost would be a little lower when equipment for the 300 MW nuclear power plants is in serial production, and that the cost to build embankments would not be necessary or needed as much, we adjusted the investment per kW of the 300 MW nuclear power plants to 2,200 yuan/kW. As for the investment per kW of the 125 MW nuclear power plants, the effect of serial production has already been considered, and the cost of 2,130 yuan/kW is for the double-pile. Since the comparison was based on the single-pile, the investment per kW was adjusted to an increase of 10 percent, which is 2,340 yuan/kW.

The construction cost was around 750 yuan/kW for large coal-fired power plants completed in 1983, and is expected to exceed 900 yuan/kW in 1990. In the comparison, the value of 900 yuan/kW was used.

## (2) Fuel Supply System Investment

No electricity can be generated by a power plant which has no fuel. Therefore, when economic comparisons of power plants are made, it is necessary to have an overall consideration of the fuel supply system. The influence of transportation of the fuel used by the nuclear power plants is very small whereas it is a big problem to consider coal coming from which area should be used in a coal power plant. From the point of rational use of coal resources, coal from Shanxi Province should be used in the coal power plants in the East China Area, and coal from Liupanshui in Guizhou Province should be used in the coal power plants in Guangdong Province. According to the data analysis provided in the "Policy Research Report of Energy Resources in China" written in 3 years by several hundred experts congregated by the

National Energy Resources Research Commission, the investment per ton of coal exploited in Shanxi Province could be taken as 120 yuan, whereas that in Liupanshui could be taken as 180 yuan. According to the research report by the Institute of Railway Science, and the Overall Transportation Institute of the State Economic Commission, if bulk coal is transported from Shanxi Province to East China a capital cost of 150 yuan per ton would be needed to expand the transportation capacity, whereas the capital cost for the coal from Liupanshui transported to Guangzhou would be 250 yuan for every additional ton of coal. If large coal-fired power plants are to be built near Shanghai and Guangzhou, the overall investment per kW of the power plant and the fuel supply system would be 1,845 yuan/kW and 2,450 yuan/kW respectively, based on the calculation that 350 million tons of coal must be mined and transported to supply a 1,000 MW coal-fired power plant.

As for the supply of nuclear fuel, it is estimated that the treating system for supplying nuclear fuel would be 510 yuan/kW in a nuclear power plant before the year 2000.

## 2. Data Related to the Cost of Generating Electricity

### (1) Coal Prices, Transportation Costs, and Coal Consumption of Coal-Fired Power Plants.

Today, coal prices in China are excessively low, and some adjustment is being considered now. It is estimated that it would reach a reasonable price in the nineties. Therefore, a predicted price of coal at that time should be used for calculating the cost of generating electricity in a coal-fired power plant in the early nineties. Today, experts from different fields have yet to reach a consensus on what this price should be. Some have suggested that it should be adjusted to the price of coal on the international market. In our opinion, this range of adjustment would be too much, and it is unacceptable. Therefore, according to the opinion suggested by the comrade in charge of the Energy Resources Economics Committee of the National Energy Resources Research Commission, after being adjusted to the early nineties, the average price of 38 yuan/ton of raw coal with a thermal value of 5,000 kcal/kg was used in our calculation. The thermal value of the coal from Liupanshui was taken as 5,000 kcal/kg, whereas that of the coal from Pingsuo, Shanxi Province, was taken as 6,000 kcal/kg.

The problem of excessively low coal transportation costs also exists. According to data from the Transportation Research Institute of the Chinese Institute of Railway Science, the national average railway transportation cost was 0.975 fen/ton-km in 1980, whereas the net transportation cost was 0.87 fen/ton-km. After 15 percent of it was turned over to the government as industrial and commercial taxes, a loss was incurred in cargo transportation in the railway departments. Owing to the fact that the transportation cost increases by folds on newly constructed lines, and the effect of price increase in different fields, it is estimated that the national average railway cargo transportation cost would rise to around 1.5 fen/ton-km in the early nineties. In order to let the railway departments have a reasonable

profit (for example, a 12 percent profit) after 15 percent of it is returned to the government as industrial and commercial taxes, the suitable average railway cargo transportation cost would be around 1.94 fen/ton-km by then. Thus, after the transportation cost by river is added, the total transportation cost would be 28.2 yuan per ton of raw coal from Pingsuo in Shanxi Province to Shanghai, and it would be 37.4 yuan for 1 ton of raw coal from Liupanshui to Guangzhou.

According to the design of the 60 MW coal power plant by the East China Electric Power Administration Bureau in the end of 1981, the coal consumption was 334 g/kWh. The value of 335 g/kWh was used in our calculation. The coal consumption of the 300 MW and the 125 MW coal power plants were 340 g/kWh and 350 g/kWh respectively.

## (2) Fuel Consumption and Thermal Efficiency of Nuclear Power Plants

Most of the average fuel consumption for the fuel assemblies of large PWR nuclear power plants designed in the seventies abroad was 33,000 MW-day/ton. But the recent operating experiences of many countries showed that the actual value has already greatly surpassed the designed value. The average fuel consumption for a certain assembly has already reached 56,000 MW-day/ton.<sup>(2)</sup>

Recently, the American Combustion Engineering Co. suggested that they could guarantee to supply us fuel assemblies with a fuel consumption value reaching 40,000 MW-day/ton.<sup>(3)</sup> Therefore, it was considered that the fuel consumption value could be used as 38,000 MW-day/ton for the large PWR nuclear fuel assemblies.

The design fuel consumption value was 24,120 MW-day/ton for our 300 MW PWR nuclear power plants, and 26,000 MW-day/ton for the 125 MW PWR nuclear power plants.

Recently, the net thermal efficiency for the latest large PWR nuclear power plants reached 34 percent. The net thermal efficiency of 33.8 percent was chosen in our calculation from the two PWR nuclear power plants sold to South Korea by Westinghouse of the U.S. in 1979. A relatively advanced value today, it would be in the general range in the nineties. The design net thermal efficiency was 27.5 percent for our 300 MW PWR nuclear power plants. As for the net thermal efficiency of the 125 MW PWR nuclear power plants, no official design data has yet been obtained. The value of 25.6 percent listed in Table 1 was reckoned from similar nuclear power plants abroad. The 125 MW PWR nuclear power plants recently designed by ourselves were not mainly for supplying electricity but for supplying heat and electricity. When the effect of supplying heat is considered, the thermal efficiency for the dual-purpose power plants is over 84 percent.

## (3) Capacity Factor of Power Plants and the Percentage of Electricity Consumption by the Plants

Recent information shows that the average accumulative capacity factor of the PWR nuclear power plants in different countries approaches 65 percent.

It approaches 75 percent in West Germany. The accumulative capacity factor of the PWR nuclear power plants in the U.S. is lower than the world average. But the accumulative capacity factors for the power plants which have been in operation for more than 7 years all exceed 70 percent. The selection for the capacity factor value of the PWR nuclear power plants is different when economic analysis of nuclear power plants is performed abroad. Seventy-five percent was suggested as the main data by the International Nuclear Energy Organization.<sup>(4)</sup> In France, 70 percent was selected as the main data.<sup>(5)</sup> Following the recent practice in some plants in the U.S., the value of 65 percent was selected by Taiwan Province of our country. Up to the end of 1981, the capacity factors of the nineteen 900 MW PWR nuclear power plants in operation in France all exceeded their design data. The capacity factors for the 600 MW PWR nuclear power plants in different countries are even better than those of the large power plants. Therefore, we decided to select 70 percent as the capacity factor of the PWR nuclear power plants. And for convenience of calculation, the capacity factor of coal-fired power plants was also selected as 70 percent.

As for the percentages of electricity consumption by the plants, they were 5 percent, 7 percent, and 7 percent for the 1,000 MW, the 300 MW, and the 125 MW PWR nuclear power plants respectively. It was 7 percent for all the three sizes of coal-fired power plants, which is a little lower than the average percentage of electricity consumption (about 7.5 percent) in the thermal power plants in China.

### 3. Calculation Method for the Cost of Generating Electricity

Usually, nine items would be considered for the cost of generating electricity, the depreciation cost, the major maintenance cost, the fuel cost, the salary of the working personnel, the cost of the consumable materials, administrative costs, etc. Among them, the sum of the depreciation cost, the major maintenance cost and the fuel cost is approximately 89 percent of the total cost. The rest of the items come to only 11 percent. The lack of detailed data makes it hard to calculate accurately the costs of the different items which only come to 11 percent of the total cost. Therefore, by adopting the general calculation method abroad, we combine these items, which are parts of the cost of generating electricity, into one item--the maintenance cost. The maintenance cost of coal-fired power plants was taken as 10 percent of the total cost of electricity in the calculation. According to the experience abroad, the maintenance cost of nuclear power plants was taken as 12 percent of the total cost of generating electricity.

According to the calculation method mentioned above, there are only three items in the cost of generating electricity: the cost of capital construction, the fuel cost, and the maintenance cost. The cost of capital construction consists of two items: the fixed assets depreciation cost and the heavy repair cost. For the fixed assets depreciation cost, 3.5 percent was used in the calculation. It is approximately equivalent to a linear depreciation of a power plant life of 30 years. The deduction percentage for heavy repair was chosen as 1.5 percent. The calculation for the cost

of this item was the same for both nuclear and coal-fired power plants. The result of the annual deduction of the investment per kW of the power plant divided by the annual hours of full operation of the power plant and revised by the percentage of the electricity consumption by the plant is the cost of capital construction.

The fuel cost of the coal power plants can be directly calculated from the coal consumption per kW of electricity, the caloric value of the raw coal, the price of the coal, and the transportation cost. This should also be revised by the percentage of electricity consumption by the plant.

The fuel cost of nuclear power plants was calculated by dividing the nuclear fuel cost in kg of uranium by the product of the fuel consumption, the net thermal efficiency of the power plant and 24. The unit for nuclear fuel consumption is usually expressed in MW-day/ton or kW-day/kg, and there are 24 hours in a day. Since MW-day or kW-day refers to thermal power, it should be converted by the thermal efficiency and the constant 24.

#### C. The Standard Used in This Article for the Economic Comparison of Power Plants Construction Projects

When options for economic construction projects are compared, many standard methods may be used as a base for selection. Comrade Xu Shoubo [1776 1108 3134] wrote in his "An Introduction to Technical Economics" that the comparison standard for economic construction projects could be written in a most wide-ranging formula. The different standards adopted abroad are specific cases of that formula. The necessary capital, labor, and resources, etc. should be considered from all aspects by using this formula for the comparison of options. But in order to do that, different standard coefficients must be determined, which demands a great amount of work. Therefore, simplification according to the actual situation is usually needed when this formula is applied. Given China's present situation, in which the sources of labor, coal, and nuclear fuel are not as tense as the lack of investment capital, when simplification of the formula is performed, only the emphasis on the consideration of capital need is necessary. Hence, only the standard coefficient for the effect of the capital need should be determined.

The determination of the standard coefficient for the effect of the capital need relates to the work of discussion and demonstration for the nationwide economical construction projects. This implies a very important bearing. In the U.S.S.R., this coefficient is jointly determined by the State Planning Commission, the State Construction Commission, and the U.S.S.R. Academy of Sciences, and is circulated throughout the country after being ratified by the Council of Ministers. It is revised through the same procedure every few years. Since the late fifties, we have not seriously engaged in such work, which has caused a lack of state standards being applied to the work of discussion and demonstration for economic construction projects for a long period and led to a situation where no regulations were followed. In February 1982, the "Provisional Regulations for the Economic Analysis of Electrical Power Engineering" was drawn up by the Ministry of Electric Power

Industry (now the Ministry of Water Resources and Electric Power). In it, the standard formula that ought to be used in an economic comparison of electric power engineering projects was stipulated, and the standard coefficient for the effect of the capital need was stipulated as 0.1, which was called the rate of investment recovery for the electric power industry in the Regulations. Two standard comparison methods were stipulated in it. The first method, namely the minimum annual cost method, was used in this article. The formula is as follows:

$$NF = Z \left[ \frac{r_0(1+r_0)^n}{(1+r_0)^n - 1} \right] + u \quad (1)$$

where:  $NF$  is the converted cost evenly distributed in  $n$  years from the year  $m+1$  to  $m+n$ . It could be called the converted investment per kW. The option from which the minimum value (for multiple options) or the lesser value (for two options) of it can be obtained is the option that ought to be selected.

$Z$  is the total investment converted to the  $m$ th year, which is

$$Z = \sum_{t=1}^{t=m} Z_t (1+r_0)^{m-t} \quad (2)$$

where:  $u$  is the converted annual operating cost:

$$u = \frac{r_0(1+r_0)^n}{(1+r_0)^n - 1} \left[ \sum_{t=t'}^{t=m} u_t (1+r_0)^{m-t} + \sum_{t=m+1}^{t=m+u} u_t \frac{1}{(1+r_0)^{t-m}} \right] \quad (3)$$

where:  $m$  is the number of years required for construction.

$n$  is the economical service years (or the economical life) of the project. For coal and nuclear power plants, it is stipulated as 25 years.

$t$  is the year in which the project starts construction.

$t'$  is the year in which part of the project starts operating.

$r_0$  is the rate of investment recovery for the electric power engineering, which is stipulated as 0.1.

Today, the effect of inflation is not considered in our country when comparison of options for economic construction projects is performed. We follow this method. Only the effect of the price increase was considered in the construction cost, and no yearly national inflation was calculated. Furthermore, not long ago, the interest for the state allocation for the construction of power plants was not considered in the cost calculation, and it is not totally considered even now. Therefore, the interest was not considered in this article. A supplementary calculation will be submitted when the state regulations on handling the loan capital construction are all clearly defined.

Some simplifications had been made when formulae 1 to 3 were applied in this article. First, only power plants with single generating units were considered in the comparison, that is: construction at the second or third stage was not considered; and that the power plants could have full power generation in the same year they are completed was assumed. Thus, the first term in brackets on the right side of formula 3 would become zero and may be ignored. Second, the difference in the capacity factors of each year during the operation period of the plant was not considered. Thus, in addition to the fact that the national inflation and interest were not calculated,  $u$  became a constant (the linear depreciation method was used, therefore the depreciation cost was a constant). The amount of calculation was greatly reduced in this way.

Five years was chosen as the construction period for both coal-fired power plants and nuclear fuel enterprises, whereas 7 years was chosen as the construction period for coal mines and transportation systems of railways or water transport. Since the recovery and the profit of the investment for the fuel supply system could be considered through the price of the fuel, it was separately calculated here. Only the annual operating cost of the power plants was calculated. It would be better if an overall investment and an overall cost could be calculated, but it would involve the prediction of a lot of primary data. Up to the present, the error of prediction is rather great, and it is difficult to get good results. Therefore, we did not follow that way.

It is not difficult to derive formula 3 from formula 1. The derivation could be found in general engineering economics textbooks. It is presented in a special article in an economics journal of our country.<sup>(8)</sup> Therefore, it is not derived here, and only its economical meaning is explained. "F" in formula 3 refers to the total investment converted to the year when the power plant is completed after the time value of the investment is considered. The second term in brackets in formula 3 refers to the total operating cost converted from the operating cost of each year to the year of completion of the power plant after the time value of the investment is considered. The fraction in brackets of formula 1 is the same as the fraction in the square bracket of formula 2. It could be called the equivalent recovery coefficient of investment capital after the time value of the investment is considered. Thus, the term "NF" in formula 1 is the converted annual cost considered totally of the investment, the operating cost, and the time value of the investment. As for the equivalent recovery coefficient of the investment capital, it is a constant of 0.1 for the electric power industry. The life of a power plant "n" is set at 25 years, also a constant. Therefore this coefficient is also a constant. Actually, formula 1 is a kind of extension of the investment conversion formula generally used. Thus, by looking at formulae 1 to 3, it is very clear that when two options of electrical engineering projects are compared, if the investment and the cost of one option are both better than those of the other, then this option is a better one and should be adopted. No more calculations are needed by using formulae 1 to 3.

#### D. The Result of the Calculation and Its Analysis

The calculated costs of generating electricity by our nuclear and coal-fired power plants by using the above mentioned calculation method and primary data are listed in Table 2 and Table 3. It can be seen from the tables that the costs of generating electricity by the 300 MW and the 125 MW PWR nuclear power plants are all higher than those by the coal power plants of the same capacity located near Shanghai, East China or the neighborhood of Guangzhou in Guangdong Province. Due to the fact that the overall investment per kW of these two nuclear power plants are also higher than those of the coal-fired power plants of the same capacity, a conclusion can be reached without calculation by using formulae 1 to 3, which is: simply from the point of view of economy of the cost of generating electricity, these two nuclear power plants are not as economical as coal-fired power plants of the same capacity. But coal can be saved from the coal-fired power plants and exported if nuclear power plants are utilized for generating electricity. This would be beneficial to the economy. Further discussion will be presented later about this.

Table 2. The Cost of Generating Electricity by Our Nuclear Power Plants  
(R.M.B. fen/kWh)

<u>Power of Plants, 10,000 kW</u>	<u>100</u>	<u>30</u>	<u>12.5</u>
Cost of Capital Construction (including the electricity consumed by the plant)	1.223	1.794	1.908
Cost of Capital Construction (excluding the electricity consumed by the plant)	1.287	1.929	2.052
Cost of Fuel	1.661	3.205	3.206
Operating and Maintenance Cost	0.402	0.700	0.717
Total Cost of Generating Electricity	3.350	5.834	5.974

The cost of generating electricity and the overall investment of the 1,000 MW nuclear power plants are all lower than those of coal-fired power plants of the same capacity in the Guangdong district. A conclusion could be reached without calculation by using formulae 1 to 3 that it is more economical to construct the 1,000 MW nuclear power plants than coal-fired power plants of the same capacity in Guangdong. Thus, the economy of constructing the 1,000 MW power plants near Shanghai is the only one that needs to be evaluated by using formulae 1 to 3.

Table 3. The Cost of Generating Electricity by Our Coal Plants (R.M.B. fen/kWh)

<u>Locations of Power Plants</u>	<u>In Area of Shanghai</u>			<u>In Area of Guangzhou</u>		
	<u>100</u>	<u>30</u>	<u>12.5</u>	<u>100</u>	<u>30</u>	<u>12.5</u>
<u>Power of Plants, 10,000 kW</u>						
Cost of Capital Construction	0.734	0.734	0.734	0.734	0.734	0.734
Cost of Fuel	2.881	2.924	3.010	3.535	3.588	3.694
Subtotal	3.615	3.658	3.744	4.269	4.322	4.428
Subtotal (excluding the electricity consumed by the plant)	3.846	3.933	4.026	4.590	4.647	4.761
Operating and Maintenance Cost	0.427	0.437	0.447	0.510	0.516	0.529
Total Cost of Generating Electricity	4.273	4.370	4.473	5.101	5.164	5.390

The results are shown in Table 4. It can be seen from Table 4 that according to the comparison standard in the "Provisional Regulations for the Economic Analysis of Electrical Power Engineering" issued by the Ministry of Electric Power Industry in February 1982, it is more economical to construct 1,000 MW nuclear power plants than coal-fired power plants of the same capacity near Shanghai. The following is a little analysis. Because of the limited space, only the sensitivity analysis of those parameters with a higher uncertainty was performed. Among the technical parameters used for nuclear power plants, up to the present, there is no full certainty whether the investment per kW could be lower than 1,500 yuan/kW. There is also no full certainty that the capacity factor could be maintained at 70 percent for a long period. As for the coal-fired power plants, the accuracy of coal prices and transportation costs is also not high. Therefore, calculations were performed to show changes in the cost of generating electricity and the investment per kW when these parameters varied. If the capacity factor of the nuclear power plants increases, the investment per kW decreases, and when coal prices and transportation costs increase, nuclear power plants would be more economical. Therefore, emphasis was put on calculations when these parameters went towards the opposite direction, and research was done to determine the change of these parameters until the construction of the nuclear power plants and the coal-fired power plants in the Shanghai area were economically the same. Thus, when the parameters continued to change in that direction which was unfavorable to the nuclear power plants, the nuclear power plants would not be so economical as the coal power plants. The result is shown in Table 5. It could be seen from Table 5 that if the investment per kW of 900 yuan/kW of the coal-fired power plants does not change, and the investment per kW of the nuclear power plants is greater than 1,615 yuan/kW, the nuclear power plants would not be as economical as the coal-fired power plants. When the capacity factor of the nuclear power plants drops to 60 percent, the cost of generating electricity would rise about 7 percent, but the converted annual cost decreases instead. This is due to the fact that the amount of electricity generated

Table 4. Cost Analysis of 1,000 MW Nuclear Power Plants and 1,000 MW Coal-Fired Power Plants Constructed in the Shanghai Area (yuan/kW)

<u>Parameters</u>	<u>Nuclear Power Plants</u>	<u>Coal-Fired Power Plants</u>
Total Investment per kW (Z)	2575.9	2317.5
Converted Investment per kW by Using the Equivalent Recovery Coefficient	283.9	256.4
Converted Annual Operating Cost	184.6	235.4
Converted Investment per kW (NF)	468.5	490.8

Table 5. The Calculation Result of the Sensitivity Analysis When 1,000 MW Nuclear and Coal Power Plants are Constructed in Neighborhood of Shanghai

<u>Kind of Power Plant</u>	<u>Varying Conditions of Parameters</u>	<u>Cost of Generating Electricity, fen/kWh</u>	<u>Converted Annual Cost, yuan/kW</u>
Nuclear	Investment per kW (including fuel) increases to 1,615 yuan/kW	3.463	489.9
Power Plants	Capacity factor increases to 80%	3.061	458.5
	Capacity factor decreases to 60%	3.452	428.8
Coal-Fired Power Plants	Coal price and transportation cost are maintained at the present level	3.238	433.8

decreases when the capacity factor decreases, and the annual operating cost is the product of the amount of electricity generated and the cost of generating electricity, and that the rate of decrease of the amount of electricity generated is greater than the rate of increase of the cost of generating it. Conversely, if the capacity factor increases, the cost of generating electricity decreases, and the converted annual cost would increase. The reason is the same as above, only the effect is in the opposite direction. It could be seen that it is not enough to evaluate the economy of a power plant simply from the point of view of the capacity factor. Several other factors ought to be considered simultaneously.

As for the coal-fired power plants, if coal prices and transportation costs of coal remains unchanged, by the late eighties and the early nineties, when nuclear power plants are constructed in serial, the cost of generating electricity by these plants would be 3 percent higher than that of the coal-fired power plants. The converted annual cost of the coal-fired power plants would be reduced to 433.8 yuan/kW, which is lower than the value of 468.5 yuan/kW for the nuclear power plants. Under this circumstance, the nuclear power plants are not as economical as the coal-fired power plants. But the present price of coal and its transportation costs are unreasonably low. It must be adjusted within 10 years. Possibly, nuclear power plants would be more economical than coal-fired power plants after the coal price is adjusted.

#### E. Conclusion

It may be seen from the above calculation that the 1,000 MW nuclear power plants constructed by ourselves would be more economical than the coal-fired power plants of the same capacity after the techniques of constructing the PWR nuclear power plants are mastered. As for the construction of the 125 MW and the 300 MW nuclear power plants, even if the coal price is raised to 38 yuan/ton, the cost of shipping coal by rail is raised to 1.94 fen/ton-km, with a corresponding increase in the cost of water transport, the direct economic effect of constructing the nuclear power plants is not as good as that of the coal-fired power plants of the same capacity. These are two major reasons why it is not as economical to construct small-sized nuclear power plants. First, the investment per kW of a power plant is high when the capacity is small. For the values of the investment per kW that we used, the investment per kW of the 125 MW nuclear power plants is 1.56 times that of the 1,000 MW nuclear power plants. This ratio is much smaller than the ratio of 2.3 abroad, and it is hard to improve on this. It is the same for the 300 MW nuclear power plants. Second, fuel consumption for medium- or small-capacity nuclear power plants is relatively low. In principle, it is impossible to reach the same fuel consumption of the large-capacity nuclear power plants. Therefore, due to technical difficulties, it is very hard to improve our medium- or small-capacity nuclear power plants, thus allowing them to compete in economic benefit with coal-fired power plants of the same capacity, provided that the coal price and the transportation costs are not greatly raised.

China is now carrying out a policy of substituting coal for oil. The intention is to substitute coal for the oil used in oil-fired power plants so that the oil can be exported for higher economic benefit. We suggest that it would be better to substitute nuclear fuel for oil by constructing nuclear power plants. But the reality is that while the oil-fired power plants of a number of chemical plants could be replaced by 125 MW nuclear power plants, there is no demand to replace 300 MW oil-fired power plants by nuclear power plants. If oil or coal cannot be substituted, it is not economically beneficial to construct more 300 MW nuclear power plants. The conclusion here is: from the point of view of economy, stress should be put on the construction of large-capacity nuclear power plants of 1,000 MW. A lot of existing 125 MW oil-fired power plants of many chemical plants should be replaced by nuclear power plants. If no oil-fired power plants could be replaced, the construction of 300 MW nuclear power plants should be considered only for the purpose of handling the technology. It is not advisable to construct more of them.

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CSO: 4013/133

## NUCLEAR POWER

### ECONOMIC ADVANTAGES OF NUCLEAR POWER PLANTS UNDERSCORED

Beijing NENG YUAN /JOURNAL OF ENERGY/ in Chinese No 2, 25 Apr 84 p 32

/Article by He Mingxing /0149 3046 2450/: "The Economic Accounting of Nuclear Power Plants"

/Text/ I. The Future of Nuclear Energy

The nuclear energy is 2-3 million times greater than chemical energy, the fission energy of 1 kg of uranium is equivalent to the energy released by burning 2,500 tons of standard coal and the fusion energy of the same mass is three times the fission energy.

The second half of the 20th century is the first stage of the development and application of nuclear energy. As of August 1982, there were 273 nuclear power plants operating in 24 countries and regions, producing a total of 168.35 million kilowatts of electric power. There were 229 nuclear power plants under construction with a total generating capacity of 215.27 million kilowatts, and 111 nuclear plants were on order with a combined capacity of 108.41 million kilowatts. It is predicted that by the year 2000 approximately half the countries in the world will have nuclear power plants and nuclear power will account for 30-40 percent of the total power output in some major western industrial nations and the percentage will be even higher for France.

#### II. Developing China's Nuclear Power

China is a large country with rich reserves of energy resources. But with 1 billion people, our per capita energy resource of China is only average among the countries in the world. In particular, China's energy resources are not uniformly distributed, coals are concentrated in Shanxi, Nei Monggol, and Henan, water resources are concentrated in the southwest and on the mid- and upper course of the Huang He and oil resources are concentrated in the east and west. The population, industry and agriculture of China, on the other hand, are concentrated in the coastal areas in the southeast. This distribution has caused great difficulties in the transportation of energy in China. In view of this situation, China must build a number of nuclear power plants in the south, the east, and the northeast where the industry and agriculture are developed and where the population is concentrated in order to relieve the shortage of energy in these regions and to promote the continued production of industry and agriculture in these areas.

## 1. Nuclear Energy Policy

China's nuclear energy should follow the policy of "Combine electric power and heating, combine peace time and wartime, and let nuclear power take the lead. "

Based on the economic analysis of nuclear power, nuclear power plants built in eastern and southern China should be primarily for electric power and those built in the north and northeast should combine electric power with heating. In order to reduce the severe pollution caused by burning coal for heating in large northern cities, such as Beijing, Shengyang, Changchun, and Harbin, roughly 20-30 450,000 kW low-temperature nuclear heating plants should be built to replace the coal-burning heating plants.

Calculations show that low-temperature nuclear heating plants are about 30 percent cheaper than coal-burning heating plants. Theoretical calculations show that they should be about 50 percent cheaper. If 450,000 kW low-temperature nuclear heating plants were built 2 kms east, west, south and north of Beijing, they could supply heat to 2.40 million people in the winter and the supply area would be 24 million square meters. As compared to coal-burning heating stations supplying heat to an equal area, the nuclear plants would cost about 30 percent less.

## 2. Investment Costs of Nuclear Power Plants

It has been estimated that it would cost 7.3 billion yuan to build a twin-reactor 1,800 MW nuclear power plant with the entire outfit imported. Combined with the costs of 30 years' supply of nuclear fuel, the total investment would be 12 billion yuan.

The cost to build a 1,800 MW coal-burning power plant plus 30 years of coal--180 million tons--and long-distance transportation costs, the total investment would be 17.7 billion yuan.

As can be seen from the comparison above, a twin-reactor 1,800 MW nuclear power plant costs 5.7 billion yuan less than a 1,800 MW coal burning power plant.

Building a series of large nuclear power plants in southern China, eastern China, and northeastern China not only costs less than building coal-burning power plants, it can also alleviate the pressure on transportation in these regions and reduce the environmental pollution in the cities and in the countryside.

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## NUCLEAR POWER

### DEVELOPMENT OF NUCLEAR POWER PLANTS VITAL TO TECHNOLOGICAL REVOLUTION

Beijing RENMIN RIBAO in Chinese 17 May 84 p 5

[Article by Zuo Hu [1563 3275]: "It Is Imperative for China To Develop Nuclear Power"]

[Text] Transformation of the existing energy structure is a cardinal problem the new technological revolution must solve. In the light of predictions by some professional institutions of the world, the following changes will surface in the global energy structure within the next 50 years: petroleum and natural gas, in their share of balance between supply and demand of energy, will drop from about two-thirds at the present time to less than 40 percent, as a result of the limitations by conditions of the natural resources; coal will rise up, but it is not likely to be in excess of one-third of the share, because of the limitations by conditions of the environmental protection; hydraulic power will continue to maintain its share of approximately 5 percent; solar energy and other renewable energy sources (biomass-energy, wind-generated energy, geothermal energy) will increase to 3-5 percent of the share; nuclear energy will grow from 2-3 percent today to over 20 percent of the share. The forecast has not placed an excessively high expectation on the contributions of solar energy and renewable energy. This is because it takes a longer period of time for the new energy technology to develop its competitiveness to a magnitude of replacing traditional energy technology on a large scale.

People base their estimate of nuclear energy massively replacing petroleum and natural gas on the following factors: 1--Nuclear power generation is already a mature technology. Practice has proved that nuclear power plants can compete with thermal power plants economically, and that the former has less effects on the environment than the latter. 2--The second-generation nuclear power plants, namely, the fast breeder power plants, are expected to be popularized around 2000. By using the fast breeder, the utilization value of the uranium resource will surpass that of existing exploitable coal resources. 3--The proportion of electric energy in commodity energies will continue to grow. 4--Coal, petroleum, and natural gas, apart from being used as fuel, are still raw materials of the various chemical and industrial products essential to food, clothing, and daily necessities, whereas the only usefulness of uranium beneficial to human society is its use as fuel for generating electricity.

The technology of using nuclear energy was born in the 1940s. The attempt to use it for generating electricity began in the mid-1950s, and it was used for popularization of industries in the 1960s. Nuclear power and the computer, the technology being developed in a same period of time, are organic components of the new technological revolution. Since the 1970s, nuclear power plants have become an important mainstay of the power industry in a number of countries, and the porportion of nuclear power plants in the total output of electric energy and primary energy has increased steadily.

China must develop nuclear power. Our country is rich in coal and hydraulic resources. It is second only to the Soviet Union and the United States in coal reserves, but it ranks first in the world's hydraulic resources. Nevertheless, there has existed an uneven distribution of energy and resources, with over 60 percent of the coal resources deposited in North China and more than 70 percent of the water resources dispersed in South-west China, being distributed mostly in industrially underdeveloped areas, whereas energy shortages exist in industrially well-developed areas, thereby creating a situation of transmitting electricity from the West to the East and transporting coal from the North to the South. This has brought about tremendous difficulties in power transmission and coal transportation and increased the pressure on communications. To alter this irrational distribution, it is necessary to build nuclear power plants in the areas experiencing energy shortages. The comprehensive costs of building nuclear power plants, as shown in all aspects of investigation and proof, are economical and reasonable. Today, in many countries of the world, the cost of electricity generated by nuclear power is lower than that generated by coal.

China has already possessed the basic conditions of developing nuclear power. Over the past 20 years, China has secured a proven reserve of the nuclear resource for use in a fairly large number of nuclear power plants; it has built up nuclear technological equipment of a considerable magnitude; and it has had a powerful nuclear technological force and the experience to use nuclear energy. We develop nuclear power, with our sight set not merely at the immediate present, but more importantly at the distant future, for this is a measure of strategic significance tha must be adopted to meet the challenges of a new technological revolution. Per capita, China is not rich in energy and natural resources. The development of nuclear energy to alter and rationalize the energy structure is an important event which concerns whether there will be a dependable energy supply in the next 50 years or so. China's building of nuclear power began late, and this requires that we try hard to catch up without letting opportunities slip by.

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## SUPPLEMENTAL SOURCES

### DEVELOPMENT OF NEW ENERGY SOURCES BY YEAR 2000 PROJECTED

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/Article by Gu Jian /7357 4148/: "Projection of New Energy Resources by Year 2000"\*

/Excerpts/ In 1983, during the process of formulating a tentative plan for new energy technologies in China, the status of the present Chinese energy industries, the current technological level and strength, the objectives of future development and technological policies to be adopted, and the initiation of major scientific and technological tasks were discussed. I had the opportunity to participate in this work. The problems discussed are summarized in this article for comrades who are concerned about the development of energy in China in order to promote the rapid and healthy development of this industry.

#### I. Historical Background and Current Status of New Energy Resources Development in China.

1. The new energy resources include solar energy, biomass, wind energy, geothermal energy and ocean energy. Since the founding of our country, the exploitation and utilization of new energy resources had a tortuous history. For example, methane and the solar stove have had ups and downs. During the "great leap forward" in the fifties, with the exception of geothermal energy, great progress was made in the exploitation and utilization of new resources from solar stoves, small windmills, methane, biomass gasification, and small tidal power stations. Because of rushing into mass action, science was neglected. Things were manufactured in a crude and sloppy manner. Most of the equipment and construction were discarded shortly afterward. Of course, that was the development in a period of time. There are more lessons than experience. However, it is worthwhile pondering that why the people had the interest

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and desire to exploit and utilize new energy resources. It was not international fashion to explore new energy resources, which was different from the development of petrochemical and electronic industries. With the exception that windmills were traditionally used, the major reason might be that the utilization of new resources could satisfy the needs of villages in China. The people could get involved on their own. This is an important point for developing new energy resources in China.

2. In the sixties and early seventies, there were ups and downs for methane and the solar stove. Back then, the solar stove received a lot of attention and was promoted in Shanghai, Jiangsu, and Henan. It was also technologically improved. However, due to its intrinsic limitation, it was dropped because there was no urgent need in those areas where it was promoted. In contrast to the practice of using solar stoves on a large scale in certain areas, one can see that the policy of suiting measures to local conditions is a historic experience. Although there were ups and downs for the utilization of methane in this period, the range was small and the effect insignificant.

3. The starting point of developing new energy resources in China began from promoting methane in Sichuan. Although the old method was used to promote the use of methane to rush the crowd into action in the seventies, leading to more waste pits and high losses, yet various levels of methane offices were established to continuously summarize the experience and lessons and to improve the technology (the national methane office held a methane workshop in 1980 to determine the policy of scientific and stable development). The foundation to promote and utilize methane nationally was thus established. In 1979, the State Science and Technology Commission held an experience exchange meeting on the utilization of solar energy and established the China Society of Solar Energy, marking a new developmental stage of new energy resources in China. The meeting emphasized the scientific and economic aspects, which clearly corrected the direction of development of new energy resources and promoted the development of solar energy utilization.

4. The exploitation and utilization of new energy resources in China is still basically in an experimental, developmental and demonstration stage. It is far away from creating trades in new energy resources.

Because of lack of statistical data, therefore, the amount of energy to be provided by new resources, or the energy to be conserved, cannot be clearly stated. Using methane as an example, the entire country has already built over 7.5 million methane generating pits. There are no statistics on the number of disabled pits, and there are large discrepancies in estimating the amount of methane generated. If a calculation is made based on an annual utilization of 200 days with 5 million methane generating pits at a utilization-to-production ratio of 0.1, the energy is approximately equivalent to that of 0.8 million tons of standard coal.

In reality, this number may not be reached. However, the major role of methane in providing energy among the new resources can be confirmed. Next is the utilization of geothermal energy. A 7,000 kW geothermal power plant has already been built at Yangbajing in Tibet. Tianjin is utilizing 270 geothermal wells, pumping 48,940,000 tons of water annually. Fuzhou has 67 outfits using geothermal energy. Approximately 5 million tons of hot water is pumped annually. In the area of utilizing hot springs in China, there are approximately 60,000 square meters of geothermal greenhouses and 80,000 square meters of warm water fish ponds. Therefore, the energy provided geothermally is approximately equivalent to 300,000 tons of standard coal. In addition, there are 150,000 square meters of solar thermal water heaters, 35,000 solar stoves, thousands of windmills and 7,000 kW of tidal power stations. It is estimated that the energy supplied by new resources is about 1.2 million tons of standard coal, corresponding to 0.2 percent of the energy consumed nationally.

5. In terms of quantity, China is leading the world in the exploitation and utilization of methane. There are also some technological standards. The number of solar stoves used is also the highest in the world. In addition, the range of application of solar cells is wider, including power sources for railroad signals, navigation lights, TV, electrified fences used in livestock operations, radio relay stations, and agricultural black lights, as well as for lighting, radio, and television in yurts. Geothermal hot water also has multiple agricultural applications. It is used in greenhouses, fish ponds, poultry hatcheries, nurseries, and irrigation projects. The comprehensive operation of a small tidal power station, such as Haishan in Zhejiang with a 150 kW capacity, can generate 29,000 kilowatt-hours of power annually, bringing in 20,000 yuan.

6. However, the exploitation and utilization of new energy resources in China has many weaknesses because time is relatively short, investment in scientific research is not much, technical resources are weak and dispersed, and research, demonstration, promotion, and production are not coordinated. In summary, the technical standards are not high, the product quality is unsatisfactory, the loss large and the economic aspect still poor. With the exception of marsh gas and solar cells, other areas have not had their bases.

## II. Direction and Goal of Development

7. In order to determine the direction and goal of developing new energy resources in China, it is necessary to study the international movement in the utilization of new energy resources. Since 1973, western countries have suffered from the impact of the oil embargo and rising petroleum prices. A few years ago, the U.S., Japan, West Germany, France, and Italy attempted to use new energy resources to replace oil. A lot of hope was placed on the utilization of new resources, especially solar energy, wind energy, geothermal energy, and ocean thermal energy. A

large amount of capital was invested in scientific research and demonstration. The progress in technology over the years has indeed been relatively rapid. However, the economic aspect is still very poor, and it has been difficult to compete with conventional energy sources. Taking solar thermal power generation as an example, the investment per kilowatt was as high as \$12,600 for a 10,000 kW experimental station built in the U.S. over 10 times higher than that of a conventional power plant. The manufacturing cost of a solar cell is \$10 per peak Watt. The construction cost of large wind power generating equipment also requires \$2,600 per kilowatt. They are much more expensive than conventional energy sources. Therefore, it is necessary to further improve the technologies to reduce costs to be more competitive. However, some new energy devices have already been produced commercially, such as solar thermal water heaters, small windmills and solar cells. Large-scale medium temperature methane generating pits using animal wastes as raw material are more economical. Passive solar energy houses are rapidly developing because they are simple and economical. Research on solar cells has drawn a lot of attention. New solar cells (polycrystalline silicon, amorphous silicon) are on the brink of a technological breakthrough. There is little progress in the energy storage technology. In the past 2 years, world petroleum prices have dropped and the trend is to continue to decline. The world oil supply is abundant, which will certainly have an effect on the development of new energy resources in the world.

8. New energy resources were never treated as replacement energy sources in China from the beginning, instead they have been used on a small scale in a scattered manner as ancillary energy sources which is different from the situations in Western countries. Based on the needs, capabilities, and current standards, we unanimously believed that the directions of new energy resources development in China in the next decade until the year 2000 should be.

(1) Aiming at villages to serve the vast peasants. It should begin with solving the energy required for living for the farmers by using new resources as ancillary energy sources. Domestic methane pits, small windmill generators, and solar stoves are the major items.

(2) Providing urgently needed and specially demanded energy resources for coastal areas, islands, mountains, pastoral areas, border defense areas, and remote areas without conventional energy resources, as well as for certain sectors in the national economy. Solar cells, medium and small windmill generators, small tidal power plants, wave power generation, and solar seawater desalination will become effective. Some areas may utilize solar-powered motors, thermal power generators, solar ponds and large windmills.

(3) Contributing toward conserving petroleum, coal, and firewood. The major aspects include geothermal power stations, step-by-step utilization of geothermal hot water, passive solar houses, solar thermal water heaters, driers, biomass gasification etc.

If new energy resources are exploited and utilized as described above, the outlook is broad and the economic aspect is also viable.

9. The utilization of new energy resources must suit the local situation, primarily depending on the resources. They are almost everywhere with the exception of geothermal energy and ocean energy. However, the abundance varies, and it is highly localized. According to the natural resources in China, the utilization of solar energy should be focused on in regions such as western China and northern China where solar radiation is intensive and sunlight time is long. Wind energy should be primarily used along the coast in Jiangsu, Zhejiang, Fujian, and Guangdong as well as some areas in Nei Monggol, Xinjiang, and Qinghai. It is much more favorable to develop ambient temperature marsh gas pits in high-temperature areas in the south than in the north. Moreover, raw materials such as straw and rice straw are readily available. The north also has favorable conditions to develop methane gas. Once animal husbandry is widely developed, large- and medium-sized medium temperature methane pits using animal wastes as raw material will be one of the developmental directions. The gasification of residual matter of agricultural and forestry products should be developed at key locations near forests. As for geothermal energy and ocean energy, the amount of resources surveyed should be used as the basis for exploitation. The focal points for exploiting high-temperature geothermal energy are Taiwan, Tibet, and western Yunnan. The North China region, including Beijing and Tianjin, Fuzhou and Zhangzhou are areas for medium- and low-temperature geothermal energy development. Tidal energy is concentrated along the coasts of Zhejiang and Fujian. Prospects for exploitation and utilization is good.

10. When considering the directions and goals, we cannot overlook the fact that new energy resources are future energy sources and will be one of the lasting energy systems. Therefore, it is necessary to act according to one's capability. Some long-range scientific research projects should be arranged as technical reserves. These projects have already taken into account the exploitation and utilization of solar photochemical hydrogen production and liquid junction cells, energy storage technologies, liquefaction of biomass, dry hot rock, ocean thermal energy conversion and energy differential in tide and salt concentration.

Plant energy sources as giant kelp should also be included as a category in the experimental studies.

11. It is very difficult to define the goals to achieve in developing new energy resources. The development of new energy sources in China is affected by many factors. Following are advantageous and disadvantageous factors based on preliminary considerations.

The favorable factor is that new energy sources are urgently required to supplement the energy deficiency in rural, island, and remote areas. Therefore, local government and people are enthusiastic. In addition, we must develop small-scale, dispersed exploitation. Relatively speaking, the technology is simple. On the basis of sound research and demonstration, it is easy to succeed. Passive solar houses built by the people and home-made small wind generators have already emerged. Even tidal power generation is being experimented with. These are good examples. The third favorable condition is that local governments have established many new energy research institutes and higher learning institutions, and the Chinese Academy of Sciences is paying attention to the study of new energy sources and some technical achievements have accumulated. A force of more than 2,000 scientific and technological personnel has been created. Based on these favorable conditions, the goals to aim for may be made higher.

However, there are some disadvantageous factors. The most important thing is that the economic prospect of the exploitation of new energy resources is poor. It is not competitive. Compared to coal, petroleum, and hydroelectric power these new energy sources are still in their infancy, and their contribution cannot yet be estimated. The nation is paying attention to new energy sources and included new energy resources and rural energy sources as a special project in planning. However, we must also take into account that the country is still in a difficult economic stage. Exploitation of energy resources and conservation will require major capital investments. The investment in new energy sources will be extremely limited. Based on these conditions, the goals to fight for should not be set too high to avoid disassociation from reality.

12. Considering the two aforementioned factors, priority should be given to the most urgently needed, technologically mature, economic and low investment projects in developing new energy sources. During the "Seventh Five-Year Plan" period, the foundation should be built to make some real contributions. The developmental goal, in the latter 10 years may be set higher. To this end, the projected goals are: Providing or conserving energy equivalent to 9,000,000 tons of standard coal by 1990, which is approximately 1 percent of the total national energy consumption, and getting up to 48,000,000 tons of standard coal which will be approximately 4 percent of the national energy consumption by then. The details are shown in the following table.

Target of Energy Provided or Conserved by New Resources  
(10,000 tons of standard coal)

Item name	1990 target	2000 target
solar energy, including solar home, solar stove, water heater, drier, and solar cell	143	990
biomass, chiefly methane	630	3,100
wind energy	15	150
geothermal energy	110	500
ocean energy	2	60
	<u>900</u>	<u>4,800</u>

### III. Technical Policy and Major Mission of Science and Technology

13. In view of the situation of new energy sources, we were very concerned about the policy problem in the process of drawing up future plans. We hope that our nation will set policies to encourage and support the development of new energy resources. In the past, marsh gas was developed rapidly, and government subsidies for the construction of marsh gas pits had a great effect. However, the subsidy to users also brought about some side effects. It seems that the government should subsidize institutions such as plants, construction teams and service companies to consequently lower the equipment cost or construction cost of the contracted project to reduce the burden of the users. This subsidy can be made using various forms, such as tax reductions and exemptions within a certain period and providing limited no-interest or low-interest loans. The purpose is to allow business and service institutions to have a certain profit in order to encourage plants to manufacture equipment for new energy resources. It may be more appropriate for the local government to make specific regulations by incorporating actual economic conditions into this policy.

14. Currently, scientific research and demonstration are seriously out of line with promotion and production, affecting the development of new energy resources. When a scientific research achievement is proven to be technologically mature and energy conserving or economically viable through testing and demonstration, it seems to be necessary to take the required administrative measures along with adopting an economic incentive policy. Plants with certain technological resources and equipment are appointed to produce new energy devices, which are required to be used under certain conditions. The utilization of certain new energy devices, such as solar water heaters, driers, and passive solar houses should be an effective measure to conserve energy. **Because** the utilization of new energy resources is highly localized, it is better for the local government to formulate a corresponding regulation.

Of course, the solution to this problem cannot rely solely on administrative action. It should mainly depend on the establishment of an entity to combine scientific research with production and expansion, or through more collaboration. Administrative action should also not be excessively used for promotion.

15. A new energy resource is a complex subject involving multiple disciplines across various trades. It is not possible to develop it on one's own requiring coordination among various departments. For example, the development of solar energy will require special reflective material, selective coatings, compatible storage batteries, and silicon material for fabricating solar cells. As another example, wind power generating equipment will require corresponding wind power generators and compatible energy storage devices. The development of marsh gas will require methane engines. Therefore, it is necessary to draw up a policy to develop special materials and equipment for new energy resources to gradually establish the corresponding new energy industries.

16. Though the exploitation of solar energy has been developed in recent years, technical problems remain. More scientific research, demonstration, and development are needed.

The utilization of low-temperature solar thermal energy has made more progress in China, especially solar thermal water heaters. However, the product quality is still not stable and the cost is still high. There are still disagreements on materials to be used. The problem of winter utilization in the north has not yet been resolved. Therefore, it is necessary to conduct in-depth research in the areas of structures, materials, seals, coatings, glazing, system assembly, automatic control, and cleaning on the basis of the present foundation in order to improve and manufacture high-quality, low-cost products to be recognized by the users. When the product model can be fixed, standardized, and then commercialized. Presently, the manufacturing cost of a square meter of hot water heater is around 150 yuan. It is capable of conserving 200 kg of standard coal after a year of use in the north. Therefore, it is necessary to invest 750 yuan to build 5 square meters of water heater to conserve 1 ton of standard coal. It is more than twice the average cost to use residual heat to save a ton of standard coal in China and is, therefore, not competitive. If the quality can be improved and cost lowered in a few years so that the investment to conserve a ton of standard coal is more or less the same as that utilizing residual heat, it may be promoted and applied on a large scale. On this basis, we should develop high efficiency flat plate collectors and vacuum tube collectors. The applications of hot water heaters should be expanded to preheat boiler water supply for industries, as well as in heating, air conditioning, agricultural greenhouses and heating marsh gas pits. Then, the economic benefits will be greatly enhanced.

Solar driers are badly needed equipment in villages. Some light-focusing grain driers were made a few years ago, but were not consolidated. In

the past 2 years, some greenhouse type or air collector type driers have been developed for drying herbs, fruit, bean curd, and rubber. Some areas have already used them and obtained apparent economic benefits. The future is promising for the research and improvement in this area. It seems that on one hand we should strengthen the research on various air collectors in order to improve efficiency and quality, while on the other hand, we should modify the system designs of solar driers specifically with respect to the various drying requirements of agricultural products in China in order to increase the economic benefits. Moreover, demonstration sites should be established at various places. Lumber drying and concrete curing by solar energy have made progress. The techniques should be summarized and improved. Testing should be expanded and applications should be spread over wide areas.

17. The passive solar home is a simple, economic and effective way to heat up a house by solar energy, receiving international attention. China built 45 experimental buildings and the results were satisfactory. In the North China area, a passive solar home can save approximately 70-80 percent of the coal for heating. Correspondingly, the construction cost only increases by 15-20 percent. It is preliminarily considered as a probable project to be greatly developed. Experimental houses have been built on the line from Qinghai to Beijing and Tianjin. Furthermore, these experimental houses were mostly designed by referring to foreign experience except that individual thermodynamic calculations were used as a basis. Therefore, we should study the design and calculation methods for various probable models of passive solar houses suited to different needs in the vast expanse of northern China. Some demonstration houses will be built in typical areas to expand the experimental areas. In some areas along the Chang Jiang basin, it is cold in the winter but there is usually no heating. In order to improve the living standard of the people, some demonstration sites should also be arranged. In the meantime, we should further study passive solar houses with a temperature lowering effect to be developed in the south.

The study of passive solar home and the utilization of the solar water heater require coordination with the local building department in order to raise the economic benefits and to spread to a wider range.

18. Solar cells are produced commercially in China. The scientific research work is also progressing in all aspects, from improving the manufacturing technology of single crystalline silicon solar cells to the studies of polycrystalline and amorphous thin films cells, as well as exploratory research on cadmium sulfide, gallium arsenide, and liquid junction solar cells. However, there is gap in comparison to the advanced standard abroad. The efficiency of Chinese-made solar cells is approximately 2 percent less than those produced in other countries. The actual cost is 2-3 times higher. We should devote to the improvement of production technology to reduce the cost of single

crystalline solar cells to 30 yuan/peak watt in a relatively short period and to optimize the assembly and the array in order to expand the applications of solar cells. We should also study low-cost silicon materials suited for making solar cells and storage batteries compatible with solar cells, as well as to further develop new polycrystalline or amorphous silicon cells to reduce the production cost to 10-13 yuan/peak Watt by 1990 and 1-5 yuan/peak Watt by 2000. One- or 2-kilowatt level or larger solar cell pilot power plants should be built.

19. Methane is a major item among the new energy sources. Several million families in the rural area are using domestic methane pits. Over the years, several hundred thousand new pits were built every year. Therefore, to study and improve the fermentation technique, to raise the gas generating efficiency, and to develop new pit building materials are the most urgent tasks. If the gas generating efficiency can be increased from the current 0.1 to 0.2-0.3, then the volume of the pit can be greatly reduced. Because the supply of cement and brick will become the limiting factor in developing marsh gas, therefore, developing red clay or thin concrete shell methane pits which use no cement or less cement is an important measure to accelerate the development of marsh gas.

We must fight for some breakthrough in the next few years.

The studies on dry fermentation and two-step fermentation have already obtained preliminary results and research should be intensified to test them with different foodstocks in various areas to achieve immediate operation.

Expanding the sources of raw materials for methane is becoming a major problem in developing marsh gas in some areas. The key is to develop animal husbandry. We should also study cultivating aquatic plants which can be used as animal feed or raw materials for methane. The comprehensive utilization of the residue is an important aspect to increase the economic benefits of marsh gas and should be studied experimentally right away.

The domestic marsh gas pit is a key point in developing methane in China. There are still many technical problems to be resolved and cannot be let go. The improvement of domestic pits cannot be neglected because of the development of large and medium marsh gas pits. Otherwise, we will fail in the last moment, which will affect the fundamental solution to the energy problem in rural areas.

20. The comprehensive study of high and medium temperature large and medium sized marsh gas pit technology is a new area in methane development in China. Several medium sized methane pits using organic wastewater from wine and alcohol plants have already been built and successfully tested. Studies are in progress to treat wastewater discharged from starch factories, sugar plants, pharmaceutical plants

and meat packing plants to generate methane. There are many small-scale methane pits using animal wastes as raw material. Studies on new technologies such as anaerobic filtration and solid expansion bed have already obtained preliminary achievements. We should expand the experimental range on the present basis to study the techniques to generate methane by treating the the organic wastewater from various industries, from easy to more difficult ones. We should strengthen the study on producing methane from animal wastes gathered in an animal farm. Based on the experience of six large methane plants in the U.S., Canada, and Italy, we believe that economically it is better to use high-temperature fermentation at 55°C rather than medium-temperature fermentation (35°C). The major link to determine the economic aspect is the value of the residue.

We must actively begin the experimental study of methane production from city sewerage and garbage.

We should pay attention to the study of effective utilization of methane, including the ancillary devices and special methane motors, generators and boilers.

21. China already has some experience in the gasification of agricultural and forestry residues. The 140 kW rice husk gas generator power plant in Wujiang County, Jiangsu has been operating normally for years. The cost to produce electricity is very low: 1 ton of rice husk can generate 110-140 kilowatt-hours of power. The residue gasification furnace developed by the China Agricultural Machine Institute and Guangzhou Energy Institute has also obtained preliminary success. We should strengthen the research work and expand the applicable range. We must notice the sources of raw materials in developing gasification of residues. Usually, residues are relatively scattered. Therefore, we should be mainly studying small- and medium-scale gasification devices.

22. The utilization of wind energy should be experimented with in three areas. The most urgent mission is to improve the quality of wind-powered water pumps. According to survey data, the cost of wind-powered water pumping along the coast of Jiangsu is lower than that of diesel engines and electric pumps. Hence, if the windmill is made durable and reliable, and the matching water pump and water drawing equipment is improved, then it may be developed very rapidly.

There is a series of studies to be conducted with regard to wind power generation technology. Because wind energy is a random energy source and the wind varies continuously, it is necessary to study the effective conversion into a constant frequency, fixed voltage alternating current, or a constant voltage direct current. It is also necessary to conduct research on storage batteries which are compatible with wind power generation and to develop a technology so that a complementing diesel generator or small hydroelectric power plant can be operated in parallel with the wind power generator system. Therefore, as we study to improve the windmills, we must also perform research on compatible speed

changing and frequency fixing devices, as well as generators, batteries and parallel grid technology. Presently, small, low-cost, durable windmill power generating devices capable of providing stable electrical energy are desperately needed on islands and in pastoral and mountain areas. We hope that various departments can coordinate and manufacture reliable products in the near future.

Another area of research is to study the use of sail in navigation from a new technological base. The use of sails is a traditional technology in China. However, it is usually used on wooden vessels. The current research is to install sails on motorized vessels to conserve energy. We hope that this work can be launched soon.

23. The mission to study the utilization of geothermal energy is also difficult. First, the geothermal resources in the nation must be evaluated, which is a long-term project. It is also the foundation for the exploitation of geothermal energy in China. The geothermal resources in key areas must be surveyed immediately. Because the investment required to drill a geothermal well is very high, surface exploration must be strengthened and geothermal data from drilling oil wells must be analyzed and studied in order to aid the necessary drilling work. Studies of plans for exploitation and utilization will be initiated based on geothermal reserves.

The effect of geothermal well drilling technology, geothermal water refilling technology and exploitation of geothermal energy on the environment must also be studied.

24. Based on the known resources in China, the step-by-step utilization of low- and medium-temperature geothermal hot water is abundant in wide areas. Xiongyu geothermal hot water at 84°C is first used to generate electricity. The temperature of the effluent is 57°C, which is used for heating. After the temperature drops to 55°C, it is used in agricultural greenhouses. Afterward, the effluent temperature, at 40°C, is used for fish farming. Then, 20°C water is used for irrigation. Of course, step-by-step utilization must be based on the local demand in order to bring about the maximum benefit. If low- and medium-temperature geothermal hot water is used only for power generation, the economic aspect is poor. The Xiongyu Power Plant is an experimental station which is used mainly to demonstrate the step-by-step utilization concept. We should thoroughly test this concept to bring about maximum benefits. We have to study the feasibility of heating and air conditioning by geothermal energy in cities and its step-by-step utilization, as well as technologies to utilize geothermal hot water industrially to resolve the hot water refilling problem.

As for geothermal power generation, based on the known resources in addition to Taiwan, we should concentrate our effort on the experimental geothermal power plant at Yangbajing in Tibet. According to the demand in Tibet and the result of geothermal surveys in southern Tibet, the scale of the Yangbajing Geothermal Power Plant should be properly expanded

or a new power plant should be built. However, the effect on the environment of exploiting geothermal energy in Tibet should be studied immediately and the hot water refilling problem must be resolved. A technological and economical feasibility study on the exploitation of high-temperature geothermal resources in western Yunnan should be done and compared to hydroelectric power.

25. The emphasis on exploitation of ocean energy in China should be placed on tidal power stations and small wave power generation technology in the near term. New construction techniques for tidal power stations, such as floating hydraulic structures, rubber gate structures, caisson methods and soft foundation treatment by explosion, should be studied. Bulb-type generators and totally tubular generator systems will be studied to lower the engineering cost and to improve the power generating efficiency.

The construction of large and medium tidal power stations must involve an in-depth investigation on the effect on the environment, navigation, aquatic products and ocean currents. Also, prevention of silting and technical problems concerning the operation of the power plant will be studied. Plans for comprehensive operation will also be investigated.

Small wave power generating devices could be studied and the capacity and applicable range are to be gradually expanded.

#### IV. Suggestions and Measures

26. The exploitation and utilization of new energy resources involve many departments. We recommended the establishment of a coordinating agency by the government. After a plan is drawn up, it will coordinate the scientific research, intermediate testing, demonstration, and fixed site production by various departments according to the plan in order to eliminate the phenomena that a great deal of low-level research is repeated, intermediate testing and demonstration encounter many difficulties, and scientific research is out of line with production. A lot of organizational work is required for demonstration and promotion and can only be effectively initiated through coordination.

27. The exploitation of new energy resources involves millions of families. It is also highly scientific and economical. Therefore, an important measure is to offer the people technical training after research achievements are evaluated and scheduled for exploitation so that the rural area will have a strong technical force during promotion and utilization (whether in the form of a professional family, construction brigade, or service company) to undertake management, maintenance and repair work. In the meantime, various levels of management and technical personnel will have to be trained to handle advanced technologies and management techniques. The direction should be clearly indicated and the propaganda work should be done well.

28. We recommended that the Ministry of Education set up new courses or special fields related to new energy resources in higher learning institutions with existing capabilities. It was also recommended that new energy resources special schools be established in provinces and cities where new energy resources are to be exploited as focal points. It is necessary to train senior and middle level technical and economic management personnel urgently needed now.

29. Historical and practical experience shows that the local government is more enthusiastic about exploiting new energy resources because villages, mountains, islands, and pastoral areas are desperate for energy. It was recommended that a local plan for exploiting new energy resources be drawn up according to the natural resources and energy demand in provinces (regions), cities and counties desperately need new energy sources. The plan should be executed according to procedures. The local research institutes for new energy resources should provide technical guidance.

30. Energy is the major limiting factor of economic development in China. Therefore, the nation is paying a great deal of attention to the development and conservation of energy resources. New energy sources cannot contribute significantly because the technology is not yet mature and the economic aspect is poor. However, as the technology is developed and production increases, the economic aspect will gradually change. This is a process to be experienced by any newly developed thing. The difference is merely the speed of development. The large and medium methane pits in the future, geothermal hot water near cities, solar water heaters and passive solar houses can all contribute significantly toward energy contribution. We hope that the county and the localities can provide more support, which is the common wish of comrades working on new energy resources.

12553

CSO: 4013/146

## SUPPLEMENTAL SOURCES

### DESIGN AND OPERATION OF JIANGXIA TIDAL POWER STATION DETAILED

Beijing SHUILI FADIAN [WATER POWER] in Chinese No 4, 12 Apr 84 p 12-18

[Article by Li Zhenrong [7115 2182 2837] of the East China Survey and Design Institute, Ministry of Water Conservancy and Hydroelectric Power: "Preliminary Conclusions on the Design and Operation of the Jiangxia Experimental Tidal Power Station"]

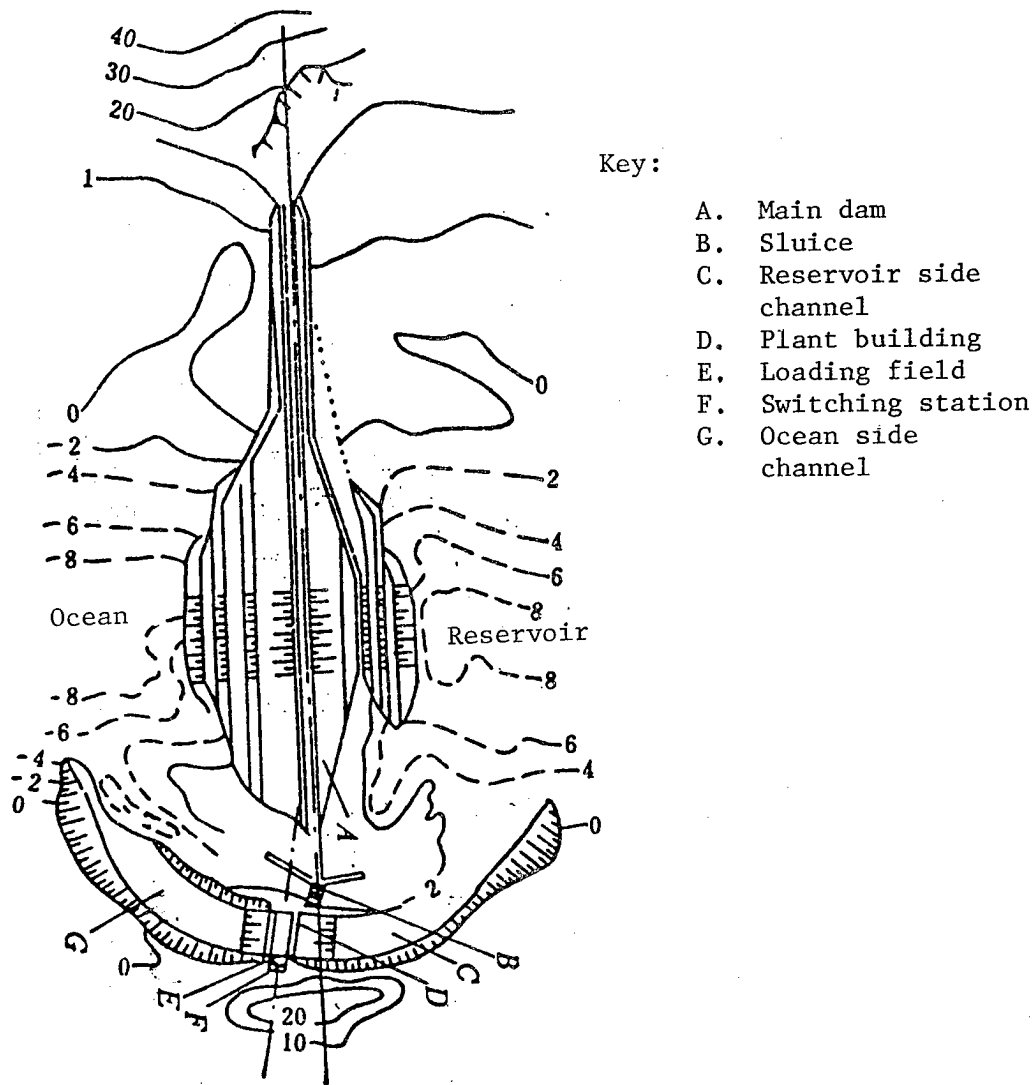
[Text] The Jiangxia tidal power station is located on Jiangxia Bay in Wenling County, Zhejiang Province. Jiangxia is a closed, half-day shallow harbor on the north end of Leqing Bay. The maximum tidal difference is 8.39 meters and the sea water has a low content of sand. The tidal power station makes use of the dike and the waterlock built by the "71" reclamation project. The main structures are the seawall, the sluice, the plant building, and the switching station. The total reservoir capacity is 93 million cubic meters and the station is built for a single reservoir bidirectional operation, that is, the generator produced electricity on the flood tide and on the ebb tide. The initial installation will be six 500 kW gravity flow bulb-type generators for an annual output of 10.70 million kWh. In addition, to the main function of power generation, the power station also affords benefits for containment reclamation, raising aquatic products, and transportation. In this paper we shall discuss several of the major design features and the operating conditions of the tidal power station.

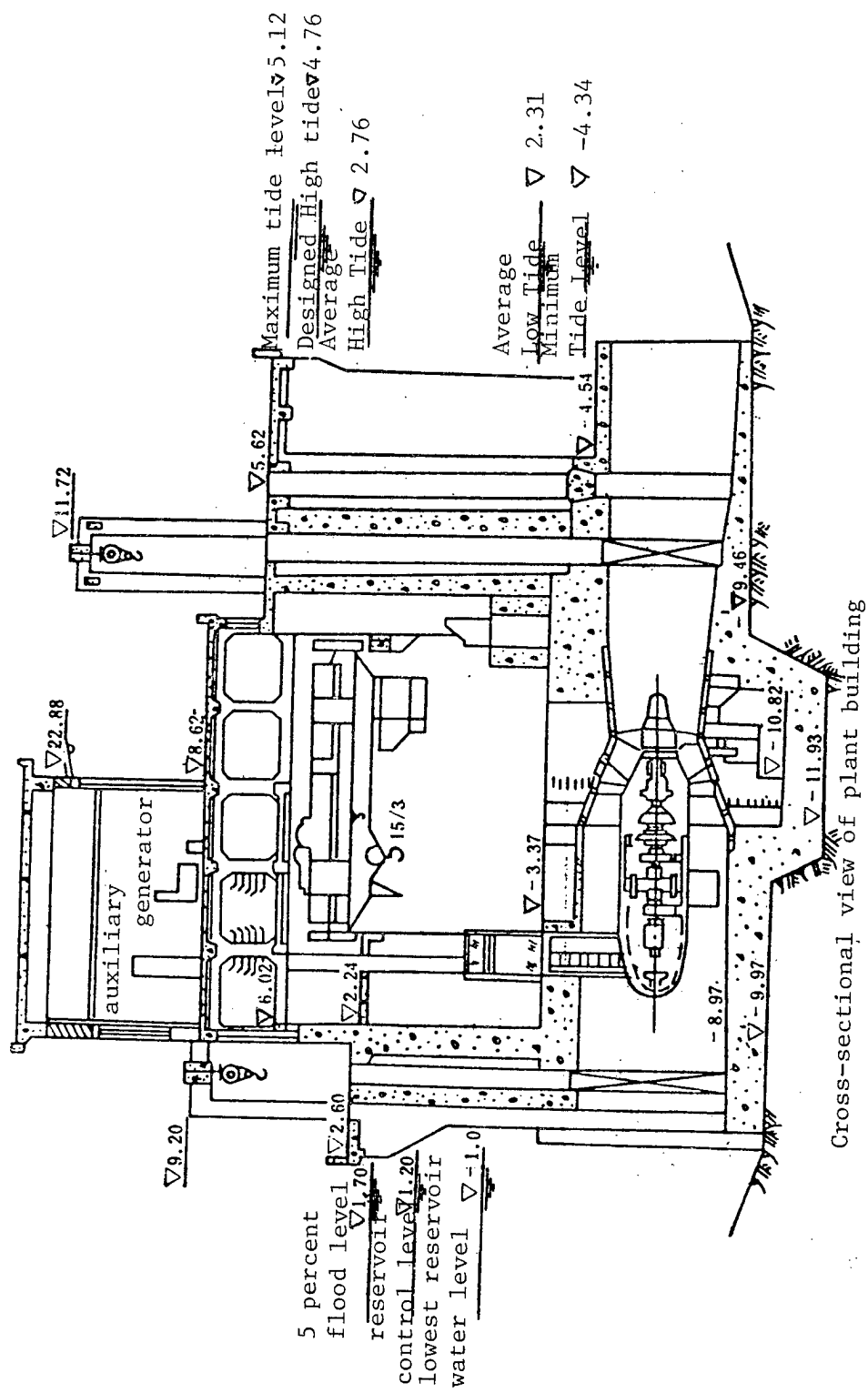
#### I. Mode of Development

Because of the elongated shape of Jiangxia harbor and the existing building structures, the tidal power station adopts a single reservoir bidirectional design. Besides generating electricity in the positive direction during ebb tide and in the opposite direction during flood tide, the sluice gate is also bidirectional. Considering the reclamation of the area around the reservoir, the water level in the reservoir for power production will be maintained at 1.2m. All water energy parameters of the power station are chosen on the principle of minimum investment for maximum power production except that the generator capacity will be increased by going through test points and the local reclamation has not been completed.

The operation and adjustment of the power station are based on the typical tide cycle, that is, a tide pattern with a monthly period including a high tide, a medium tide, and a low tide and the average high tide level, the

# General Layout of the Jiangxia Tidal Power Station





average low tide level and the average tide difference are close to or equal to the long-term average values. The operation is also based on the characteristics curve of the GZN-005 generator and the discharge characteristics of the sluice. To simplify the operation, calculations were made using the output limit curve of the generator and the corresponding overflow curve and the larger overflow was chosen to make up for the loss in efficiency.

When the water level difference between the reservoir and the ocean is less than 1.25 m (initially 1.0 m), the generator is turned on and the gate is opened to discharge water. When the two levels are equal, the gate is closed and the generators shut down. When the water level difference is greater than 1.25 m (initially 1.0 m), the generators are turned on to produce electricity. Thus, the gate is opened four times and closed four times each day, during the two highs and the two lows, to regulate the water level in the reservoir. But this operating procedure is not unchangeable, unidirectional ebb tide power production is also possible during a small tide. Table 1 shows the water energy parameters of the power station and Table 2 shows the power production calendar hours per solar day at different frequencies.

Table 1. Water energy characteristics of the tidal power station

Item	Final phase. 6 generators running	Early phase, 1 generator running
Reservoir water level:		
Control level (m)	1.2	1.2
5 percent frequency design level (m)	1.7	1.7
Minimum level (m)	-1.6	-1.6
Reservoir area at control level (km <sup>2</sup> )	2.0	2.0
Reservoir capacity:		
Volume at control level (10 <sup>4</sup> m <sup>3</sup> )	493	493
Effective volume for power production (10 <sup>4</sup> m <sup>3</sup> )	278	278
Flood prevention excess volume (10 <sup>4</sup> m <sup>3</sup> )	87	87
Tide Levels:		
Maximum high tide (m)	5.12	5.12
Design high tide (m)	4.76	4.76
Average high tide (m)	2.76	2.76
Minimum low tide (m)	-4.34	-4.34
Average low tide (m)	-2.31	-2.31
Power production water head:		
Design water head (ebb tide, forward/ flood tide, reversed) (m)	2.4/3.42	2.4/3.42
Maximum water head (forward/reversed) (m)	3.9/3.53	3.75/3.75
Minimum water head (m)	1.25	1.0
Design water head confidence level (forward/reverse) (percent)	40.3/2.3	27.3/8.9
Annual output (10 <sup>4</sup> kWh):	1070	196
Flood tide (reversed) (10 <sup>4</sup> kWh)	457	99
Ebb Tide (forward) (10 <sup>4</sup> kWh)	613	97
Annual power production time (hr):	5860	6400
Flood tide (reversed) (hr)	3300	3630
Ebb tide (forward) (hr)	2560	2770
Generator utilization time (hr)	3570	3920

Table 2. Power production time per solar day

Tide pattern	Power production time (hr) per solar day
High tide (5 percent frequency):	19.2
Flood tide	10.0
Ebb tide	9.2
Medium tide (50 percent frequency):	17.0
Flood tide	9.4
Ebb tide	7.6
Low tide (95 percent frequency):	12.6
Flood tide	7.6
Ebb tide	5.0

The No 1 generator of the power station started operation on 4 May 1980 and logged 10,472 hours and 3.56 million kWh up to October 1983. From 9 December 1980 to 26 December 1981 it was shut down for repair due to wear damage in the speed increaser and vapor erosion. On average the generator runs 15-16 hours per day and the average annual output is 340 kW. The average monthly output is 150,000 kWh and the maximum is 162,000 kWh. The power production schedule of the station is devised according to the tidal forecast and the generator output limit curve. The output differs from the power production based on the actual tide level curve by only 2.5 percent, indicating the feasibility of the scheduling method. The initial water head of the forward ebb tide power generation is 1.0-1.1 meters and the reverse flood tide waterhead is 1.1-1.2 meters. For small tides lower than -1.5 meter, the station operates in the unidirectional ebb tide mode to obtain 50 percent more output than the bidirectional mode. In order to generate more electricity during the ebb tide, the reservoir water level is usually raised or lowered 1 hour after the maximum or minimum tide level to create a greater waterhead. Since only one generator was running in the beginning, the water discharge was limited and relied mainly on the discharge from the sluice gate. A comparison of the actual operating data in 1982 and the design target (see Table 3), the actual output was 350,00 kWh too low and annual generating time was 1,691 hours short. This was mainly due to generator testing, system maintenance, cultivation activity in the reservoir and discharge of flood water. In the Table, the forward power production, operating time and rated output are all above the designed targets. The same is not true for the reverse direction because only the unidirection mode is used at low tide.

Table 3.

Data item	Designed condition			Operating condition		
	Forward	Reverse	Total	Forward	Reverse	Total
Reservoir control						
water level (m)	1.2	1.2		1.2	1.2	
Design head (m)	2.5	3.42		2.55	3.50	
Design head assurance						
rate (percent)	27.3	8.9		33.4	7.2	
Single machine capacity						
capacity (kW)	500	500	500	500	500	500
Annual output ( $10^4$ kWh)	97	99	196	108.3	52.8	161.1
(percent of whole year)	49.5	50.5		67.2	32.8	
Utilization hours			3920			3220
Annual power						
production hours	2770	3630	6400	2923	1786	4709
(percent of whole year)	43.3	56.7		62.1	37.9	
Rated output operating						
hours	755	322	1077	978	127	1105
(percent of annual						
hours)			16.82			23.47

## II. Design and Operation of the Bidirectional Generator

In the development of the Jiangxia bidirectional generator, 20 sets of S-type two-way blades were tested. The test results of the first two-way power generation and two-way water relief turning wheel are as follows:

### 1. Power production

Model efficiency: 76.5 percent forward, 54.5 percent reversed. Maximum model efficiency 81.2 percent forward, 70.7 percent reversed. Unit rotational speed  $n_1'$  at design point: 170 rpm forward, 170 rpm reversed. Unit flow rate  $Q_1'$  at design point: 2700  $\ell$ /sec forward, 2500  $\ell$ /sec reversed.

### 2. Sluice operation

When water is being drained in the forward and in the reversed directions, the guide vanes open to the maximum and the rake of the blade is  $\phi = +40^\circ$ . During the fly of the positive discharge,  $n_{1p} = 184$  rpm and  $Q_1 = 5820$   $\ell$ /sec. During braking,  $n_{1p} = 0$  and  $Q_1' = 3950$   $\ell$ /sec. In the reverse direction,  $n_{1p} = 152.3$  rpm and  $Q_1 = 3880$   $\ell$ /sec during fly and  $n_{1p} = 0$  and  $Q_1' = 1740$   $\ell$ /sec during brake.

The machine is a model GZN 005-wp-250 horizontal bulb rotating vane unit consisting of a water turbine, a planet gear speed increaser and an electric generator. The water turbine wheel has a diameter of 2.5 m, a waterhead in the range of 0.5-5.5 m and four S-shaped two-way blades with a blade angle

of  $-5^{\circ} \sim +40^{\circ}$ . The guiding mechanism has 8 fixed guide vanes and 16 movable guide vanes. The movable guide vanes may be adjusted together with the blade. The waterhead for power generation is monitored by the water level gauges on the reservoir side and on the ocean side and by the water level difference gauge in the central control room. The governor of the water turbine is a model BDST-100 unit and the oil pressure device is a model YS-1. In order to satisfy the operating requirements for the four different combinations of power generation and water drainage in the positive and in the reverse directions, the layout has the bulb upstream, the bulb ratio is 0.8 and the hub ratio is 0.38/0.33. The lubricating oil for the water turbine bearing is cooled by the externally circulating seawater. The water turbine is connected to the generator via the model 2Z-ZJ planet gear speed increaser to increase the rotational speed from 118 rpm to 500 rpm. The transmission power of the planet gear is 600 kW. Since the  $GD^2 = 1.2 \text{ ton-m}^2$  of the generator requires the flywheel to have a  $GD^2 = 1.92 \text{ ton-m}^2$ , a 1.6 m diameter flywheel is installed on the generator end. The generator (model CX 143/32-12) is housed in the bulb and is air cooled. Its terminal voltage is 3,150 volts,  $\cos \phi = 0.9$  and it uses a semiconductor brushless exciter. The exciter has a model 2X-5 mechanical rotational speed sensor which sends out signals for over speed and rated speed. For a guide vane close time of 4 seconds under the designed waterhead, the maximum speed rise of the water turbine is calculated to be 50 percent, and the pressure rise is 40 percent. Table 4 lists the water turbine data for the four operating conditions.

Table 4. Water turbine data for four operating conditions

Generator conditions	Forward (ebb tide)	Reverse (flood tide)
Effective water head (m)	0.8 ~ 5.5	0.8 ~ 5.5
Designed water head (m)	2.5	3.4
Rated output of water turbine (kW)	545	545
Rated speed of water turbine (rpm)	118	118
Planet gear speed increase ratio	4.24	4.24
Rated generator speed (rpm)	500	500
Rated generator output (kW)	500	500
Designed flow rate ( $\text{m}^3/\text{s}$ )	28	28.3
Rotation direction (as viewed from the generator side)	clockwise	counter clockwise
Fly rotational speed ( $K_p < 2.5$ ) (rpm)	295/1250	295/1250
	Fixed vane for 4.5m head, blade angle 25)	Fixed vane when head 4.5m, blade angle 20)
Axial thrust (ton)	19.6	27.5
Turbine installation height (m)	-6.72	-6.72
Blade setting angle	27.6°	15°
Blade open angle	60.6°	100° (actual $\alpha = 90^{\circ}$ )
Efficiency (percent)	79.3	67
Sluice condition	Forward (ebb tide)	Reverse (flood tide)
Fly flow rate ( $\text{m}^3/\text{s}$ )	36	23
Brake flow rate ( $\text{m}^3/\text{s}$ )	21.5	10
Fly speed (rpm)	65.8	54.6
Discharge water head (m)	< 0.8	< 0.8

After 5 months of test run, the No 1 machine worked quite well. However, the following problems were uncovered in the operation:

1. The wear damage was caused mainly by imperfect machining and insufficient supply of lubricating oil in the gear box. The problem was later solved by using a different gear material and improving the machining accuracy, heat treatment and lubricating system.

2. Oil leaks in the high pressure chamber and the low pressure chamber of the oil reservoir caused the oil pump to start frequently. The principal causes are the excessive clearance of the axial bearing and the large gap between the main pressure valve and the valve housing of the governor. The problem persisted even after careful honing of the oil reservoir sleeve to reduce the clearance from 0.33-0.54 mm to 0.26-0.29 mm.

3. The outlet edges of the four turning wheel blades were eroded on both sides. The erosion depth was generally 3-4 mm and the maximum depth was 7mm. The erosion gradually decreased from the edge of the blade to the wheel nave. The total eroded area was 0.8 m<sup>2</sup>. The main reason for the v por erosion was that the positive S type blades causes a negative pressure at the outlet. After using stainless steel welding and then polishing the surface, no obvious erosion was observed.

4. When the machine was shut down and the oil pressure to the turning wheel inner chamber cut off, seawater leaked through the "λ" shaped seal of the blade into the oil chamber at a rate as high as 1.5 l/min. The subsequent practice of maintaining oil pressure after shutdown to prevent the leakage of sea water has resulted in oil leak. Finally the oil leak was stopped by adding press-down springs and blots to the seal. Also, the double seal of the rotating part did not have a large enough pressure difference between the inner chamber and the outer chamber (15 m head in inner chamber and 13 m head in outer chamber), and could not compress the 3 mm seal gap. As a result the sealed fresh water leaked excessively. After adjusting the axial clearance from 3 mm to 0.8-1.45 mm, the leakage rate was reduced from 5.8m<sup>3</sup>/hr to 0.98m<sup>3</sup>/hr. In addition, the sea water eroded the surface of the steel seal of the maintenance shroud and an operating error in the test run ground through the maintenance shroud and incapacitated the water proof function of the seal. This problem was resolved by adding a erosion resistant stainless steel cladding, increasing the wall thickness and reducing the gap of the seal.

### III. Corrosion and Contamination of Metal Structures and Ocean Buildings

Seawater and marine life cause severe corrosion and contamination of the water turbine, other metal structures, and ocean buildings of the tidal power station, the prevention of corrosion and contamination is therefore a key problem in the construction of the tidal power station. Jiangxia harbor is located on a bay on the southeast coast where the weather is warm, water

is shallow, flow speed is low and the abundant nutrients helped a large variety of marine species to multiply rapidly. Since 1972 we have conducted 51 series of tests of different material and coating suspended in seawater at the station site. Guide vane coating tests were also performed at the nearby Shashan tidal power station. Through these tests, we have basically understood the variety and growth of marine species in Jiangxia harbor. It was decided that the first generator would have a corrosion and contamination resistant coating and an external current cathode protection, in the meantime there would be a seawater electrolysis apparatus standing by to solve the contamination problem of major components as blade, guide vane and water turbine after the coating failed. The second generator would have seawater electrolysis and external current cathode protection. Low concentration (1 ppm) chlorine was used in the electrolysis of the seawater, the chlorine was applied after the machine was shut down and the guide vane closed. When the machine was running, the large flow speed prevented marine life from adhering to the structures and the application of chlorine was not considered necessary. The seawater cooling system of the bearing oil also had electrolysis protection to prevent the marine life from adhering to the system. Experience over the last 3 years showed that metal corrosion and marine life contamination were prevented by the measures just described.

The concrete and reinforced concrete used to construct the power station met the design requirements for marine structures. Based on the temperature conditions of the construction site and the way the structure makes contact with seawater, different specifications were placed on the water-cement ratio, strength and seepage resistance, thickness of the reinforced layer, quality and quantity of the cement used, the amount of tricalcium aluminate in the cement and the maintenance, crack prevention and surface treatment of the concrete. The surface treatment method was mainly carbonization in the atmosphere for 14-21 days so that the calcium hydroxide released in the hardening process may combine with carbon dioxide in the atmosphere to form a thin and water insoluble calcium carbonate layer and improve the surface compactness. The design also called for the coating of the submerged part of the plant building with epoxy bitumen to prevent corrosion and seepage. As to marine life contamination of the plant structure, only the flow channel that affected the loss of waterhead was considered.

#### IV. Silt Problem

The accumulation of silt affects the successful operation of a tidal power station. In 1973 the water flow and silt in Jiangxia harbor were monitored continuously for 1 year. Results show that the silt comes from the East China Sea and the average particle size is below 0.02 mm and the annual average silt content is 0.064 kg/m<sup>3</sup>. The volume of the Jiangxia reservoir is 4.97 million m<sup>3</sup>, including 2.15 million m<sup>3</sup> of the dead volume and 2.78 million m<sup>3</sup> of effective volume for power production. Using Oort's [?] equation for reservoir silt accumulation and assuming that 156,000 tons of silt enter the reservoir each year, the dead volume will be filled up in 15 years and 80 percent of the reservoir volume for generating electricity will be filled up in 28 years. If electric power production is only one way on the ebb tide and if the reservoir water level for power production is not controlled, then it would take 61 years to fill up 80 percent of the

power production reservoir volume, 33 years longer than the lifetime for two-way power production. But the actual silt accumulation in Jiangxia is different from that of typical rivers and also different from most coastal containment reclamation and jetties. In Jiangxia the tidal flow is continuous and back-and-forth and the water is quiet only during brief moments. The silt is fine and does not precipitate easily. Although the construction of a dam will affect the equilibrium of the original seabed, a new equilibrium will be reached and hence a new limit of the reservoir capacity. If we estimate the new equilibrium bed level using the initial flow speed of the silt, assuming the lowest water level as the new control level of the sea channel and taking the power production water level to be 1.2 m, then the new capacity will be 3.50 million  $\text{m}^3$  and approximately 30 percent of the capacity will be lost to silt accumulation. Although the silt content in the water at Jiangxia station is low, the silt peak still should be avoided to keep the silt out of the reservoir, that is, the generator and the sluice should be closed for 1 hour during the silt peak. This practice will let 26,700 tons less silt into the reservoir per year although it reduces the power output by 878,000 kWh. In addition, agitation and dredging will also be used to reduce silt accumulation. The actually measured silt content, after the power station was in operation, was  $0.107 \text{ kg/m}^3$ . Comparing the reservoir profits measured in 1982 and in 1972, there are 10-30 cm of accumulation on the two sides of the reservoir below a height of 1.2 m. However, the keep harbor was deepened for more than 1 meter and the accumulation inside the reservoir is not very noticeable.

#### V. Tide Changes Due to Dam Construction

Another problem encountered in the construction of tidal power stations is that the construction of the dam will change the tide behavior and directly affect the design of dam height, generator installation height and machine capacity. The tide difference at the Jiangxia power station is deduced from the tide level correlation curve before and after dam construction by the Kanmen ocean hydrographic station and by the Wushamen station. The building of the dam lowers the low tide level by 9 cm and raises the high tide level by 2-6 cm. Overall, the tidal difference at Jiangxia harbor will be increased by 10 cm or so after the construction of the dam.

#### VI. Electrical Design

The situation of a tidal power station is different from an ordinary hydro-electric power plant. The following considerations were taken into account in the design.

1. The power station is located right next to the ocean, to reduce the corrosion effect of the salty air, the step-up switching station is placed indoors.
2. In the bidirectional operation the phase constantly changes. In order to maintain a fixed phase sequence on the output line, two generating lines are installed on the high-voltage side of the main transformer. The upper generating line has a fixed phase and the lower generating line has the inverted

phase. There is no phase inverting switch between the two generating lines. Also, since the tidal power station produces electricity intermittently and requires frequent phase reversals, sulphur chlorofluoride switches are used as phase reversal switches. The design called for model CN<sub>2</sub>-10 ceramic switches for the generator output line, but since they were not available, oil free switches were used instead.

3. Because the tidal power station has a large number of units which need be started simultaneously, the designed scheme would start 6 units simultaneously and engage the generator circuit breaker and the manual no-load exciter under a low rotational speed. The six units would adjust and become one effective unit under low speed and low voltage and the 35 kV breaker would engage all six units into the grid in an automatic quasi-synchronous operation. In order to avoid excessive circulation shock due to variations of voltage, phase and frequency in the synchronization process, a synchronous over current protection is added in the relay protection device.

4. The automation of a tidal power station is different from that of a conventional power station because the tidal power station requires different open angles of the guide vanes and the blades under different status and the requirements on the auxiliary unit and the automation devices are also different. Therefore, a centralized status control system is installed in the central control room and a common set of waterhead signal units consisting of water level senders and level difference receivers send out the switching pulses to change the working condition and the status control system automatically switches the operating mode of all the units. The junction line of the status control system is controlled by an interlocking program based on the status sequence. The actual operation of the power station showed that although there were frequent startups and shutdowns and sluice gate operations the oil-free switches and the sulphur chlorofluoride switches worked well. The secondary electrical system also worked well except that poor quality of individual components led to some errors.

## VII. Economic Efficiency of the General Exploitation

In addition to producing electricity, a tidal power station also benefits containment reclamation, aquatic cultivation, transportation, marine, chemical, and tourism enterprises.

### 1. Power production

Assuming the power station produces 10 million kWh per year, the annual income from electricity charges will be 400,000 yuan. Using the local value of production of 3 yuan per kilowatt-hour, the increase in annual value of production will be 30 million yuan, representing 8 percent of the country's value of agricultural and industrial production.

### 2. Containment reclamation

Containment reclamation above the 1.2 meter design level of the reservoir would produce 4,000 mu of reclaimed land. Later, the local people, following their own bent, built dikes and reclaimed 5,600 mu, including 4,700 mu of

arable land. Based on a reclamation fee of 2,000 yuan per mu, this is close to 10 million yuan of value. Today the 4,700 mu arable land have been planted with various crops. The annual income from the crops is 440,000 yuan not counting organes and will be 1.32 million yuan when organes are included.

### 3. Cultivation

The construction of the reservoir changed the natural environment. The number of young razor clams has decreased but shellfish have increased. For example, there were no clams in the past, but in last year 500,000 jin of clams were caught in the reservoir. After the construction of the reservoir, the water is quiet and the bait is abundant, the new environment is even better than the natural environment for cultivation. Outside the reservoir, razor clams take 1 year to mature, but inside the reservoir they take only 3-4 months. Today, fishing in the reservoir still relies on the naturally occurring aquatic products. In the area of artificial cultivation, 160 mu of oysters were cultivated on rock slabs in 1981 and each mu produced 1,400 jin for an annual income of 179,000 yuan. In 1982, the power station tried 0.9 mu of oyster cultivation on rubber strips and harvested 2,592 jin of oyster meat at 2,300 yuan per mu. The county aquatic products bureau intends to cultivate 500 mu of oyster on 2,400 mu of water surface to produce 1.15 million yuan income per year. In addition, 143 mu of water surface in the containment reclamation zone have been cultivated and produced 6,442 jin of large shrimp at a value of 42,000 yuan in 1982.

### 4. Other benefits

After the power station is built the road between Yuhuan, Chumen, and Wenzhou will be shortened by 30 kilometers. The reservoir also provides tourism development and extraction of important elements such as potassium, sodium, uranium, bromine, and iodine from the sea water.

## VIII. Investment Analysis

The project cost for the intial power station of two generators was budgeted for 4.71 million yuan and the final six generators for 7.122 million yuan. Now the final account of the first phase construction is 6.018 million yuan, 30 percent more than the budget amount. With the No 2 generator and the phase II construction, the total investment will be about 11 million yuan. The operation of the No 1 generator shows that the daily change of the tidal amplitude is greater than anticipated. If the design waterhead of the other generators can be changed from 2.5 m to 3 m, then the total generating capacity will reach 3,900 kW and the construction cost per kilowatt, not counting investment sharing from general exploitation, will be 2,800 yuan. There were various reasons that led to the cost overrun, if these were eliminated, the construction cost per kilowatt would have been 2,500 yuan, already approaching the construction cost of hydropower stations on coastal rivers in eastern China. With the investment shared by containment reclamation, citrus fruit, crops, and aquatic products, the per kilowatt construction cost is less than 1,000 yuan.

## Conclusions

1. The Jiangxia tidal power station is China's first bidirectional power production and water discharge experimental station. After 3 years of operation, it has met the bidirectional requirements and the power production and machine output have also reached the designed level. Contamination and corrosion prevention measures worked well and the building structures successfully endured the various tide levels. The silt accumulation problem people worried about does not seem to be a problem according to the present operating conditions.
2. Since containment reclamation by the local people took up some reservoir capacity, the waterhead must be raised to above the original design in order to maintain the original reservoir capacity and power output. To insure the safety of the hydraulic structure, the power station can only raise the water level during the non-flood season, that is, the reservoir water level is controlled so as not to exceed 2.1 meters in the case of flood. Otherwise, the original designed water level of 1.2 m must be adhered to.
3. Since the Jiangxia power station is a modification based on the original "71" containment reclamation project, the work volume is naturally greater than that of an ordinary power station. The capacity of the reservoir would allow a 10,000 kW power station, but considering that the power station and the reclamation in the reservoir are experimental in nature, the scale was reduced. For this reason, it is not valid to use Jiangxia as an example in the evaluation of the economic efficiency of tidal power stations.

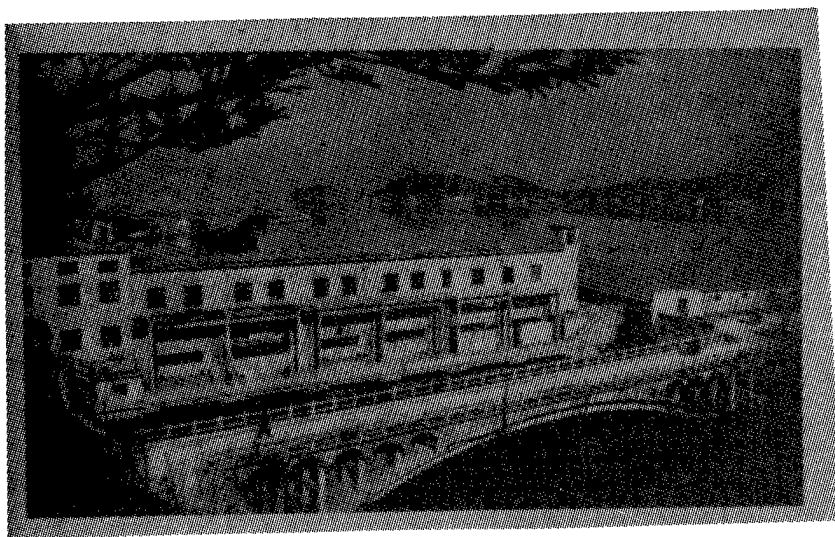
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CSO: 4013/162

SUPPLEMENTAL SOURCES

JIANGXIA TIDAL POWER STATION BEATS SEMI-ANNUAL TARGET

Hangzhou ZHEJIANG RIBAO in Chinese 28 Jun 84 p 1



[Text] As of yesterday, China's largest tidal power station--Wenling's Jiangxia Tidal Power Station--had generated 1.21 million kilowatt-hours of electricity, 53.3 percent of the year's plan. Two generators have already been installed at the Jiangxia Tidal Power Station for a total installed capacity of 1,200 kilowatts.

CSO: 4013/197

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